#133 NOVEMBER 1987

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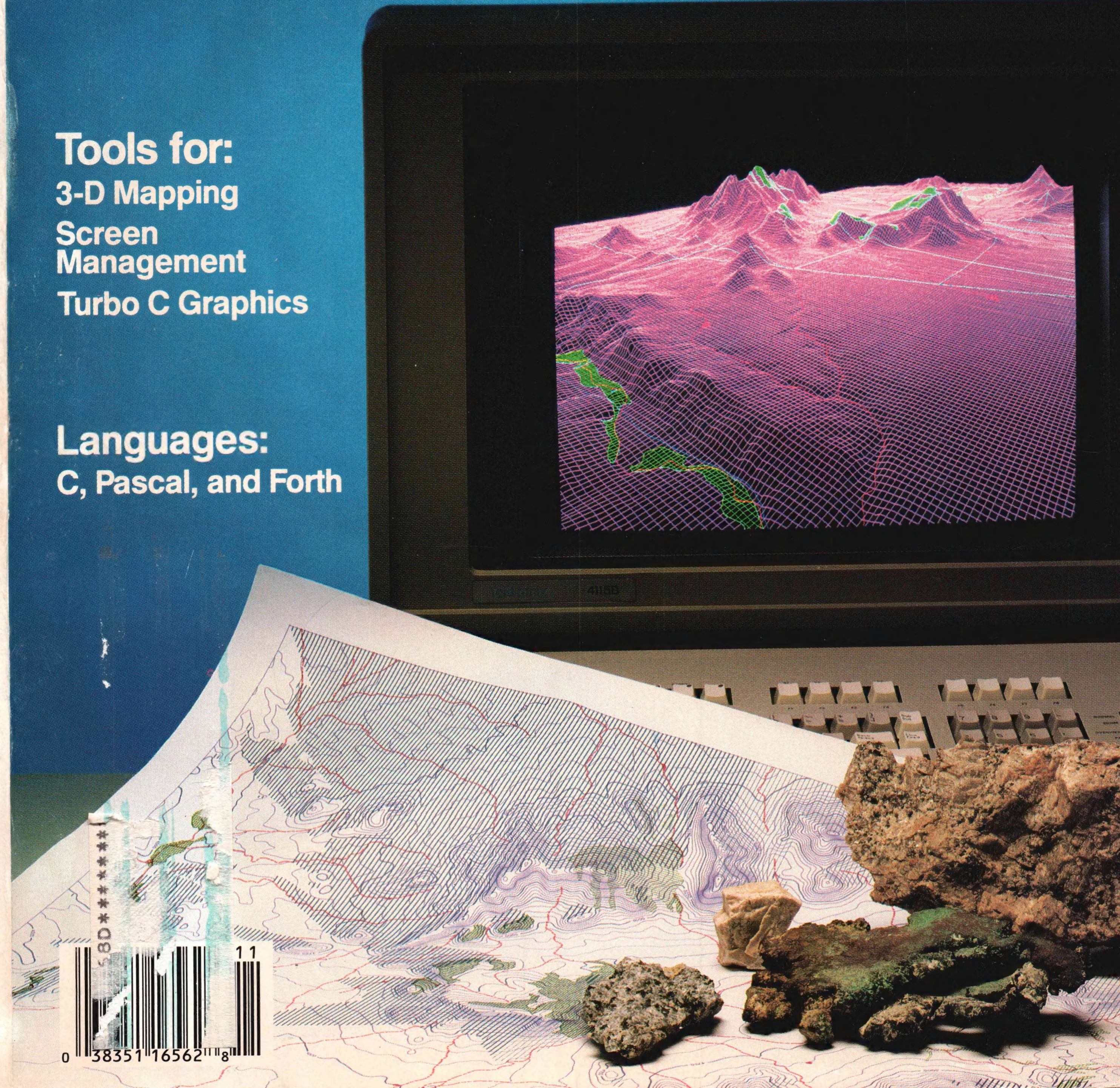
Dr. Dobb's Journal of Software Tools

FOR THE PROFESSIONAL PROGRAMMER

Special Graphics Issue



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Screen Management
Turbo C Graphics

Languages:
C, Pascal, and Forth

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4.0 uses logical units for separate compilation

Pascal 4.0 lets you break up the code gang into "units," or "chunks." These logical modules can be worked with swiftly and separately—so that an error in one module is seeable and fixable, and you're not sent through all your code to find one error. Compiling and linking these separate units happens in a flash because your compiling horsepower is better than 27,000 lines a minute.* And 4.0 also includes an automatic project Make.

4.0's cursor automatically lands on any trouble spot

4.0's interactive error detection and location means that the cursor automatically lands where the error is. While you're compiling or running a program, you get an error message at the top of your screen *and* the cursor flags the error's location for you.

4.0 gives you an integrated programming environment

4.0's integrated environment includes pull-down menus and a built-in editor. Your program output is automatically saved and shown in the output window. You can Scroll, Pan, or Page through all your output and know where everything is all the time. Given 4.0's integration, you can edit, compile, find and correct errors—all from inside the integrated development environment.

You'll never lose your mind, because 4.0 never loses your place

Whenever you re-load 4.0, it remembers what you and it were doing before you left. It puts you right back in the editor with the same file and in the same place as you were working last.

*Run on an 8 MHz IBM AT.

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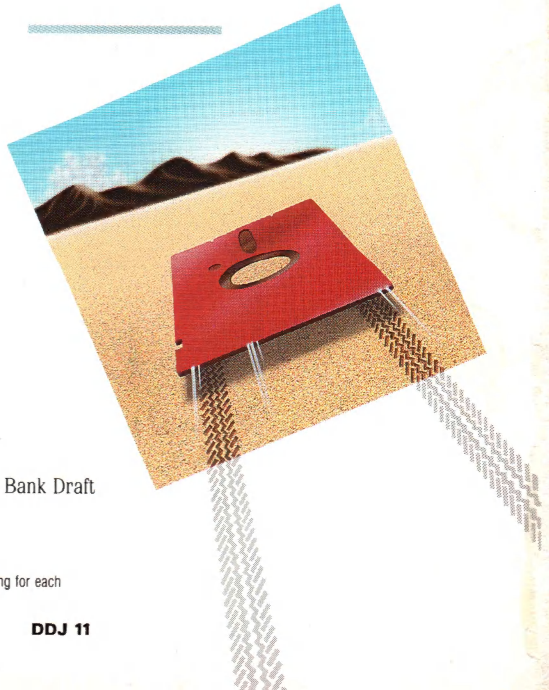

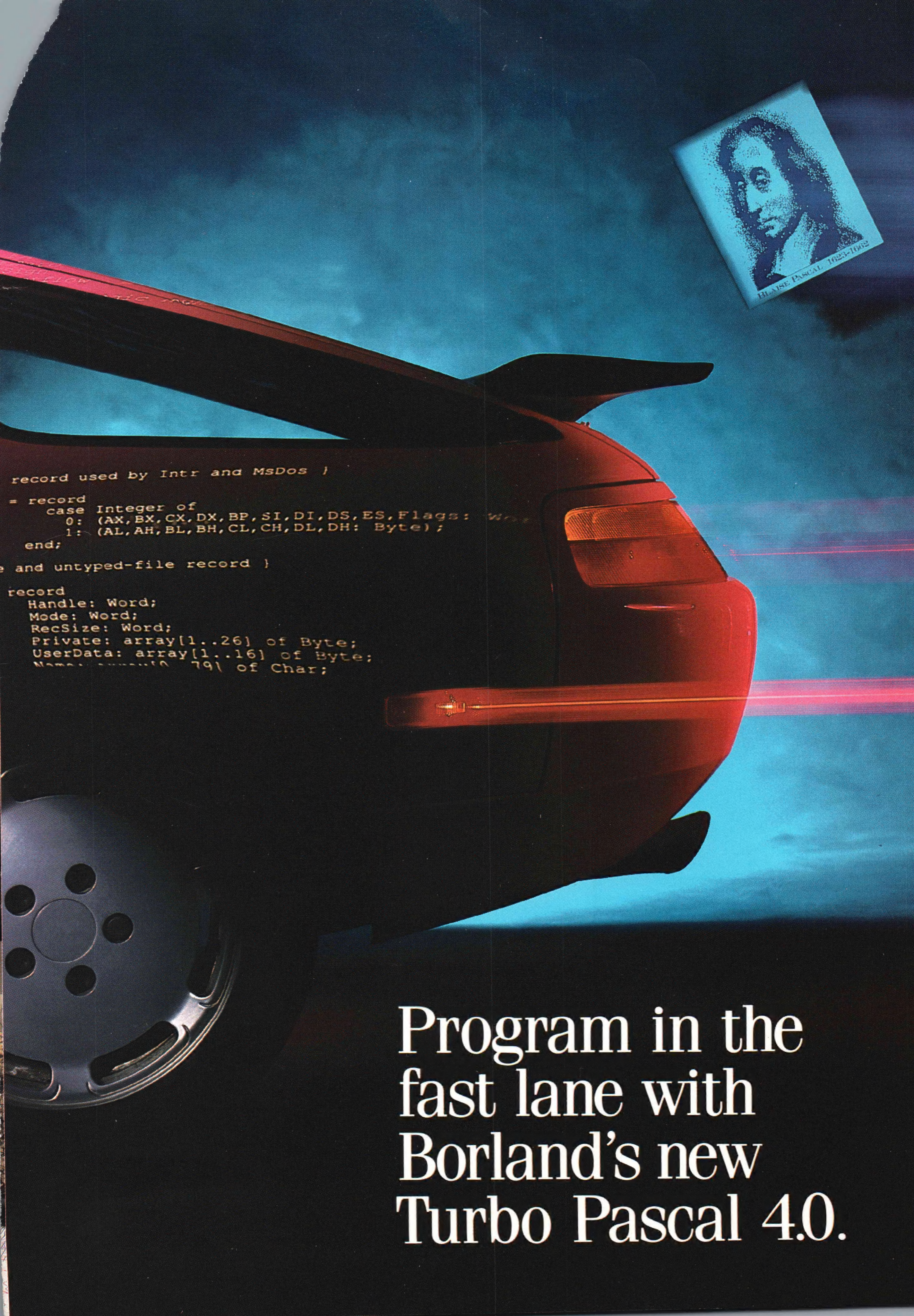
BLAISE PASCAL 1623-1662
Program in the fast lane with Borland's new Turbo Pascal 4.0.

```
 record used by Intr and MsDos }

 = record
     case Integer of
       0: (AX,BX,CX,DX,BP,SI,DI,DS,ES,Flags: Wo
       1: (AL,AH,BL,BH,CL,CH,DL,DH: Byte);
   end;

e and untyped-file record }

 record
    Handle: Word;
    Mode: Word;
    RecSize: Word;
    Private: array[1..26] of Byte;
    UserData: array[1..16] of Byte;
    Name: array[0..79] of Char;
```

The fast lane is *fa*

Our new Turbo Pascal® 4.0 is so fast, it's almost reckless. How fast? Better than 27,000 lines of code per minute. That's much faster than 3.0 or any other Pascal compiler and the reason why you need 4.0 today.

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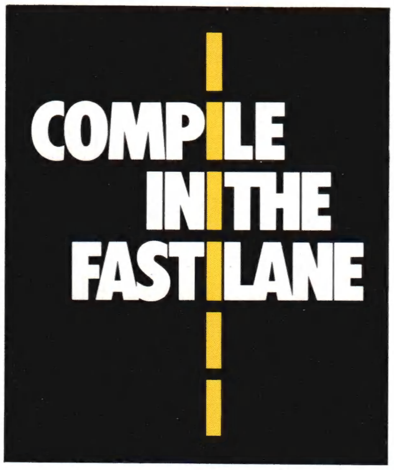

superiority also means commitment to detail, however painstaking, and that takes time. 4.0's predecessor, Turbo Pascal 3.0 is the worldwide standard, and with Turbo Pascal 4.0, we've bettered that standard. 4.0 is clearly the world's fastest development tool for the IBM® PS/2 series, PC's and compatibles—and the world's favorite Pascal compiler.

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No more swapping code in and out to beat the 64K code barrier. Designed for large programs, Turbo Pascal 4.0 lets you use every byte of memory in your computer. You paid for all that memory, now you can use it freely.

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- Compiles 27,000 lines per minute
- Supports >64K programs
- Uses units for separate compilation
- Integrated development environment
- Interactive error detection/location
- Includes a command line version of the compiler

4.0 also

- Saves output screen in a window
- Supports 25, 43 and 50 lines per screen
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- Supports extended data types (including word, long integers)
- Does smart linking
- Comes with a free revised MicroCalc spreadsheet source code

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Sieve (25 iterations)

	Turbo Pascal 4.0	***Turbo Pascal 3.0***
Size of Executable File	2224 bytes	11682 bytes
Execution speed	9.3 seconds	9.7 seconds

Sieve of Eratosthenes, run on an 8MHz IBM AT

Since the source file above is too small to indicate a difference in compilation speed we compiled our GOMOKU program from Turbo Gameworks to give you a true sense of how much faster 4.0 really is!

Compilation of GO.PAS (1006 lines)

	Turbo Pascal 4.0	***Turbo Pascal 3.0***
Compilation speed	2.2 seconds	3.6 seconds
Lines per minute	27,436	16,750

GO.PAS compiled on an 8 MHz IBM AT

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Magic is easy with Turbo C TOOLS in your bag of tricks. New Turbo C TOOLS™ from Blaise Computing is a library of compiled C functions that allows you full control over the computer, the video environment, and the file system, and gives you the jump on building programs with Borland's new C compiler. Now you can concentrate on the creative parts of your programs.

The library comes with well-documented source code so that you can study, emulate, or adapt it to your specific needs. Blaise Computing's attention to detail, like the use of function prototyping, cleanly organized header files, and a comprehensive, fully-indexed manual, makes Turbo C TOOLS the choice for experienced software developers as well as newcomers to C.

Turbo C TOOLS provides the sophisticated, bullet-proof capabilities needed in today's programming environment, including removable windows, "sidekickable" applications, and general interrupt service routines written in C.

The functions contained in Turbo C TOOLS are carefully crafted to supplement Turbo C, exploiting its strengths without duplicating its library functions. As a result you'll get functions written predominantly in C, that isolate hardware independence, and are small and easy to use.

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◆ **INTERRUPT SERVICE ROUTINE** support for truly flexible, robust and polite applications. We show you how to capture DOS critical errors and keystrokes.

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◆ **RESIDENT SOFTWARE SUPPORT** lets you create, detect, and remove resident utilities that you write with Turbo C TOOLS.

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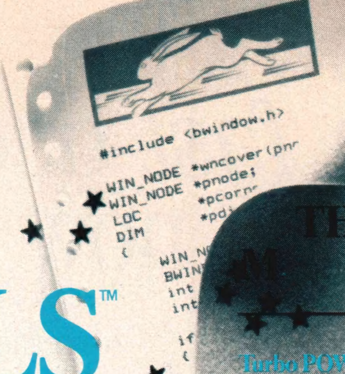
◆ **DIRECTORY AND FILE HANDLING** support let you take advantage of the DOS file structure, including volume labels and directory structure.

In addition to Turbo C TOOLS, Blaise Computing Inc. has a full line of support products for Microsoft, Lattice and Datalight C, Microsoft Pascal and Turbo Pascal. Call today for details, and make magic!

Turbo C TOOLS supports the Borland Turbo C compiler, requires DOS 2.00 or later and is just $129.00



```
#include <bwindow.h>

WIN_NODE *wncover(pnr
WIN_NODE *pnode;
LOC      *pcorne
DIM      *pdi
{
    WIN_N
    BWIN
    int
    int

    if
    {
```

THE BLAISE MENU

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NOVEMBER 1987

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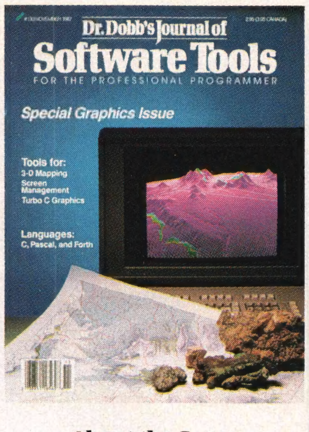
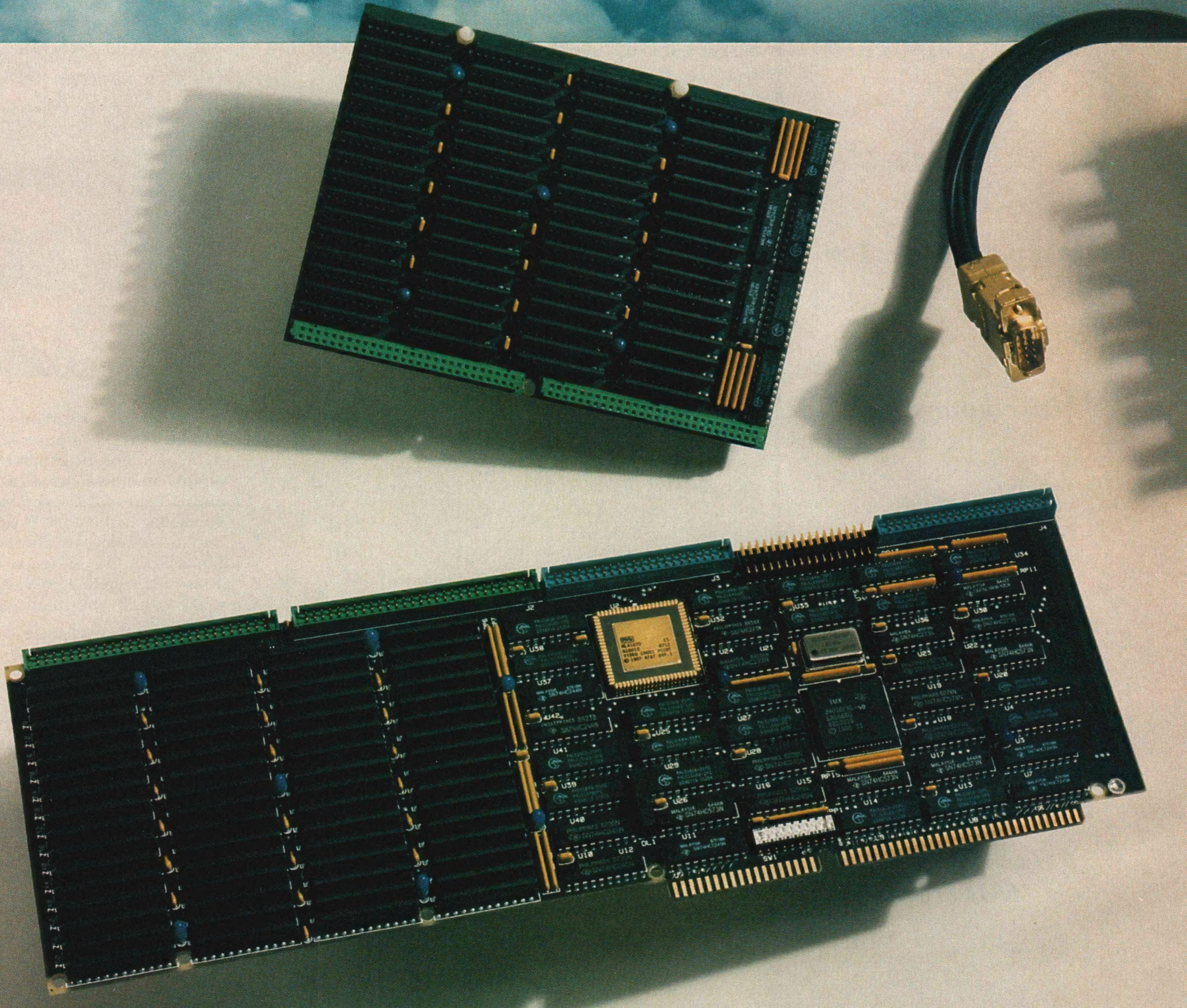


About the Cover
As you may have guessed, we didn't produce the contour map on this month's cover on the art department's 512K Mac. Thanks, you folks at Dynamic Graphics Inc. in Berkeley, California, for the use of the software, Vax, Tektronix terminal, and data to make this month's cover happen.

This Issue
Programming is getting more like cinematography every day. Welcome to our graphics programming issue, with coverage ranging from how to handle contour maps on the Macintosh to how to shuffle screen regions on the PC. There's even a library for handling graphics in Turbo C.

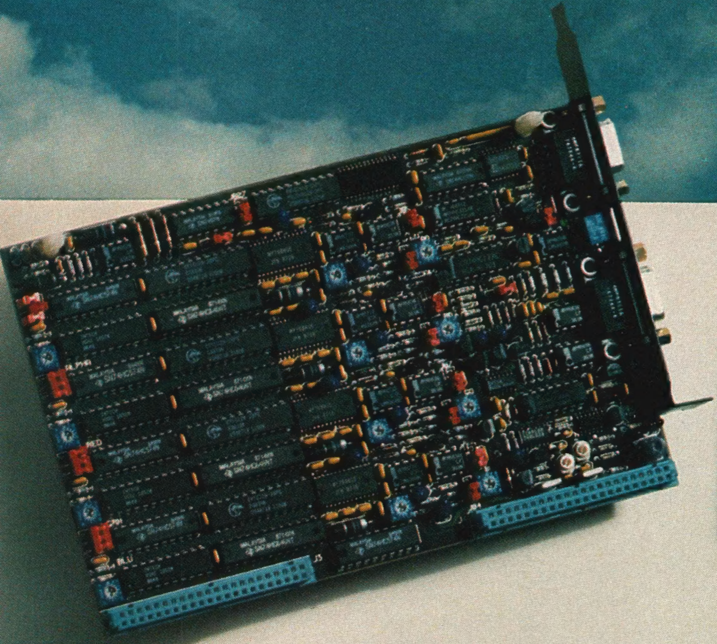
Next Issue
December is our annual operating systems issue. The lead article comes from Dave Cortesi (the Resident Intern, for those of you who remember his column from the old days) and concerns one of the less explored aspects of OS/2: dynamic linking. Allen Holub's column will detail a new multitasking kernel, and we'll also present some keen-edged blades for system hacking.

Now Taking Applications.

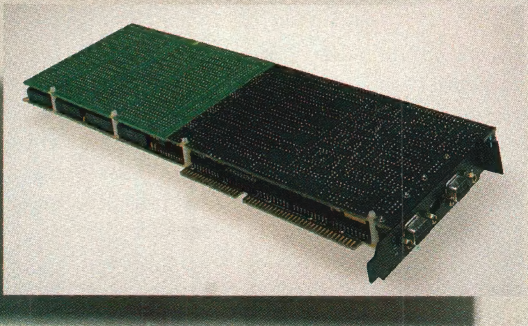


Take a look at the specs on VISTA™, a good look. Notice the processing, programming, and video capabilities? Now think real hard about what *you* could do with the power of VISTA and a microcomputer. Incorporate it with your system to create a digital pre-press proofing station for publishing. Design a graphics workstation which outputs both colorful hi-resolution slides and broadcast-quality animated images. Construct a CAD system which merges computer generated images with real-life backdrops for architecture, packaging or other industries. And, after you've brainstormed your way to new horizons of videographics possibilities, get your own VISTA and start working.

Introducing VISTA™ Videographics.



VISTA is a powerful single-slot videographics adapter which captures and displays video signals in real time.



Let's Get Specific.

We knew you couldn't resist seeing the facts, and frankly, our engineers wouldn't have it any other way. Here is an overview of VISTA's key features.

FEATURES:

- 4Mbytes of Video RAM on-board
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- Flexible, programmable resolutions
- NTSC and PAL compatible
- Four 8-bit channels for real-time capture
- Fully integrated genlock
- Processor memory expandable in 2Mbyte increments to 12Mbytes
- Four 2K x 8-bit CMOS static RAM LUTs
- Display can be color-mapped, RGB, or a versatile combination of both
- Interlaced and non-interlaced display
- Binary and fractional programmable zoom capability, creates horizontal and vertical magnify or minify
- Smooth horizontal and vertical programmable panning, includes wrap-around and split screen
- Suggested Retail Price: $5995.

ADDRESSABLE RESOLUTIONS:

32 bits/pixel	16 bits/pixel	8 bits/pixel
1024x1024	2048x1024	4096x1024
512x2048	1024x2048	2048x2048
256x4096	512x4096	1024x4096

CAPTURE RESOLUTIONS:*

NTSC	PAL
(RS-170A)	(CCIR-624)
756x486	738x576
604x486	590x576
504x486	492x576
432x486	422x576

Resolutions are programmable; these are nominal ones for interlaced NTSC and PAL compatible.

DISPLAY RESOLUTIONS:*

NTSC	PAL	Interlaced	Non-Interlaced
(RS-170A)	(CCIR-624)		
1512x486	1476x576	1024x768	768x576
1008x486	984x576	(60 Hz)	(50 Hz)
756x486	738x576		
604x486	590x576	768x768	756x486
504x486	492x576	(80 Hz)	(60 Hz)

*Resolutions are programmable; these are nominal ones.

COMPUTER REQUIREMENTS:

Host Type:	IBM PC AT and 100% Compatibles, Compaq 386, Apollo DN 3000-single-slot board
Data Bus:	16-bit or 8-bit (self-configuring)
Bus Clock:	6MHz to 12MHz
Power Consumption:	15 Watts

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EDITORIAL

Mike's Survey

We've just seen the results of our annual reader survey, so we now know more about you and your interests. We know that you are educated: most of you have done graduate work. You're forward-looking: you're more likely to use LISP or PROLOG than COBOL or even Modula-2, and if you or your company don't already have a 386 machine, you probably will buy one or more in the next year. You have professional access to a wide choice of machines, operating systems, and environments for software development.

Not entirely coincidentally, we're just wrapping up the editorial calendar for 1988. You can look forward to coverage of a wide range of programming environments: Unix, OS/2, the Macintosh environment, Windows, and DOS. We'll publish code in PROLOG, LISP, PostScript, C, Pascal, assembly languages, Forth, and BASIC. We'll examine the shift in programming style to object-oriented, event-driven design, we'll . . . .

We'll gladly, as always, alter the plan to accommodate new developments and the treasures of the transom. Which is where you come in.

What follows is a list of topics that interest us, beyond the languages and operating systems mentioned above. Survey results indicate that they also interest you. You can influence us in two ways. The first is to write us an article on one of the listed topics (or another of your choosing). The second is to let us know where you'd like to see us invest our efforts in the coming year. Treat this page as a ballot and check your favorite topics. Send me your choices. I promise to read them.

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editor-in-chief

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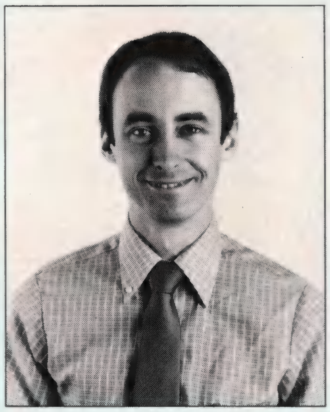

As Mike Swaine mentioned on page 6, we've just received the results of our latest reader survey. After spending some time pouring through the data, I've still got a few things I'm curious about—items that are important to producing a quality magazine but don't often show up in the statistical abstracts.

For example, we devote a lot of space to source code listings. The question is, are you folks really using those listings? Given there's always a limit to the number of pages in an issue, should we keep printing the listings as they are or print more articles and arrange for source code to be distributed some other way?

There's ample historical justification for printing source listings, of course. The reason *DDJ* was founded, after all, was to put tools such as the source code for Tiny BASIC into the hands of as many people as possible. If you wanted your computer to do something back then, for the most part you had to write the program yourself. (Sometimes you'd have to write an interpreter or compiler first and then get back to the original problem.) A dozen years ago, the hacker ethic demanded we put source code into the hands of our readers, and we did it gladly.

But that was a dozen years ago, and things have changed a bit. These days Bill Gates isn't paranoid about hobbyists copying his cassette BASIC; instead he's justifiably worried about Philippe Kahn stealing his languages market. The economics of the eight million PCs out there (a conservative estimate, by the way) have caused many sophisticated compilers to be priced so that it doesn't make sense to pirate the products, let alone write them yourself.

Fine, I hear you say, but what has all this to do with *Dr. Dobbs?*

Simply put, the field is changing and *DDJ* must grow and adapt to keep up. There's no question that Tiny BASIC ported to the AMD 29000 would be an interesting exercise in assembly language, but surely there are more useful projects to use as an example of 29000 programming. (For those of you coding for the 29000, yes, that was a hint for article suggestions.)

The question is not whether the Doctor's pride and joy will change, but how. To get back to the topic of source listings: Most of you have a modem or easy access to one. In a time when 2,400 bps modems are readily available, does it make sense to print listings so that you can enjoy hours of typing practice? Do you want more downloading options or is CompuServe access sufficient? Finally, do you use the code in binary form or just scan the printed listings to understand the algorithms?

As always, I'm willing to discuss this topic with you by phone, if you can catch me at my desk. I'll certainly be watching the CompuServe DDJ Forum to catch the debate and as the pile of papers hiding my desk will attest, we do read all your letters. But if you really want to make sure I get your vote/suggestion/threatening letter, the best bet is to use the mail systems on CompuServe (#<TK>) or BIX ('tyler').

Tyler Sperry

Tyler Sperry
editor

ARCHIVES

Linguistic Overbyte

"Programming languages appear to be in trouble. Each successive language incorporates, with a little cleaning up, all the features of its predecessors plus a few more . . . . The Department of Defense has current plans for a committee-designed language standard that could require a manual as long as 1000 pages. Each new language claims new and fashionable features, such as strong typing or structured control statements, but the plain fact is that few languages make programming sufficiently cheaper or more reliable to justify the cost of producing and learning to use them . . . .

For twenty years programming languages have been steadily progressing toward their present condition of obesity; as a result, the study and invention of programming languages have lost much of their excitement. Instead, it is now the province of those who prefer to work with thick compendia of details rather than wrestle with new ideas."—*John Backus, 1977 Turing Award Lecture.*

Ten Years Ago in *DDJ*

"Microsoft's BASIC for the 8080 and Z-80 . . . is now generally available on both a single-copy and OEM basis. The BASIC became the subject of extended legal dispute which resulted in the termination of an exclusive license to MITS, Inc.

"The BASIC, best known in the field as Altair BASIC, has been in use for 1½ years and has a user base of over 5000."—*news release,* DDJ, *November/December 1977.*

"In his letter in the *DDJ* #18, Phil Karn mentions problems regarding semi-transparent paper tape. I wonder if he has tried using polarized light. Two inexpensive pieces of polarizing material, one above the tape and one below, might solve the problem. Light would still filter through the tape, but would be de-polarized in the process and would be rejected by the second polarizer. Light passing through the holes would still be polarized and be picked up by the sensors. I haven't tried it, but it should work"—*Jim Day, letter to the editor,* DDJ, *November/December 1977.*

DR. DOBB'S JOURNAL of COMPUTER Calisthenics & Orthodontia
Running Light Without Overbyte

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You've seen the ads: Datalight challenges Microsoft. Our C compiler expert Richard Relph saw the ads and sent for Datalight's compiler. What he found when he began to test it must have given him mixed feelings. For the past two years Richard has been involved in developing the DDJ suite of benchmarks for C compilers. The Datalight compiler flattened those benchmarks, making them worthless.

With the apparent glut of C complier suppliers vying for the MS-DOS market, it was only a matter of time before one of them decided to step above the crowd and provide a reliable optimizing C compiler. Datalight beat all others to the punch by delivering such a compiler February of this year. (Dr. Dobbs Journal, August 1987)

ROM-*it*, The ROM Developer's Kit

ROM-*it* adds the functionality required by serious ROM developers. **ROM-*it*** includes pre-written start-up code for an embedded system to take the 8086 processor from a system RESET to executing C code. The library included has standard C functions that are usable in a ROM environment, without any hidden calls to MS-DOS or the BIOS. Lastly, the BLAZE Locator/Intel hex file generator performs location of code and data while it checks for ROM overflows, illegal data access, and complete program location.

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DR. DOBBS, August 1986

"This is a sharp compiler!... what is impressive is that Datalight not only stole the compile time show completely, but had the fastest Fibonacci executable time and had excellent object file sizes to boot!"
COMPUTER LANGUAGE, February 1986

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- Multiple memory model support
- Interrupt handling in C
- Make utility
- EZ editor
- DLC one step compiling
- Start-up code for 8086
- ROMable library (without hidden MS-DOS calls)
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- View source code as it executes on target
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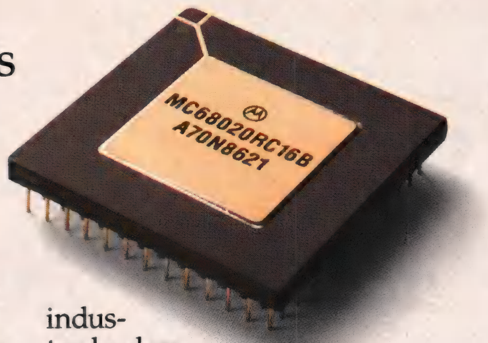

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The MC68020 is not just the overwhelming choice in workstations–it is now setting new performance standards in the office–where it is essential to the computation, graphics and communication necessary for interconnected systems.

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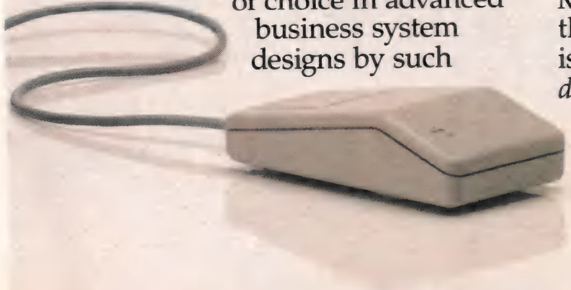

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MOTOROLA

LETTERS

8088 Optimization Techniques

Dear *DDJ*,
I enjoyed Tom Disque's article on 8088 optimization techniques (July 1987) but must point out a simple improvement to his Example 1.

He uses a *jcxz* jump to guard against counter *cx* entering a *rep movsw* with a value of 0. Although this would be a necessary prelude to an ordinary loop, where *cx* is tested at the bottom after decrementation, it is wasted before a *rep* prefix. As explained in *The 8088 Book* by Russell Rector and George Alexy (pages 4–46), a check for *cx* = 0 is the very first step in a *rep* instruction, and when it is true initially, the string primitive is not executed.

Particularly for anyone whose use of the computer reflects the name the French give to it—*L'ordinateur,* a machine for putting things in order—the string primitive instructions are among the 8086 family's most distinct advantages and such situations arise frequently. Bearing in mind this behavior of the *rep* prefix and the *cx* register can save both time and memory as well as giving programmers one less detail to worry about.

Paul R. Emmons
438 W. Chestnut St.
West Chester, PA 19380

Dear *DDJ*,
I read Tom Disque's article in the July issue, on 8088 optimizing techniques, with great interest.

As a Motorola-biased programmer, I found it interesting to note that Mr. Disque's 68000 code suffered from an Intel-type restriction. The code itself was very good, but it limited the amount of memory that could be moved to a maximum of between 64K and 256K, depending on the alignment of the memory. Although Mr. Disque used *long*-size instructions when manipulating the length registers, the *dbf* instruction could only loop a maximum of 64K times.

The *dbf* instruction can easily be extended to cope with 32-bit loops by following it with the instructions:

```
sub.1 #$10000,<register>
bcc.s <loop_label>
```

In Mr. Disque's routine, the solution is to replace the branch to exit after *longloop* with the lines:

```
sub.1 #$10000,d0
bcs.s exit
bra.s longloop
```

and to insert the lines:

```
sub.1 #$10000,d0
bcc.s lngloop2
```

after the second *dbf.* The last *dbf* does not need modification as it only ever moves 14 bytes at most.

With these changes Mr. Disque's memory-move routine can then cope with the complete addressing range of all the 680x0 processors.

Andrew Pennell
The Old School, Greenfield
Bedord, MK45 5DE
England

Legacy of the Teletype

Dear *DDJ*,
In the December 1986 Letters column there was a letter from a Mr. Hawkins in which he was complaining among other things about the terseness of the C language. He attributed this "propensity for the least possible typing" to the authors of the language being two fingered typists. More likely it was what they were typing on that inspired them to opt for the least possible typing. C is an older language than many realize since although it was born in the early 1970s along with Unix, it did not escape from its birthplace, the Bell Laboratories, until around 1980. The standard terminal in use back in the early seventies was the teletype machine. In many operating systems from CP/M to Unix the abbreviation TTY, used for things related to the terminals, makes sense only if it is realized that the terminals were originally teletype machines.

The teletype machine was an electromechanical device, not an electronic device, and was therefore very slow by today's standards. Typically it operated at 110 baud or ten characters per second. Furthermore, after a key was struck you had to wait a full tenth of a second before striking the next key or it would be ignored. Since most people, especially when thinking at the keyboard, tend to

Jared's wardrobe—like his programming—isn't EGA compatible.

(continued on page 138)

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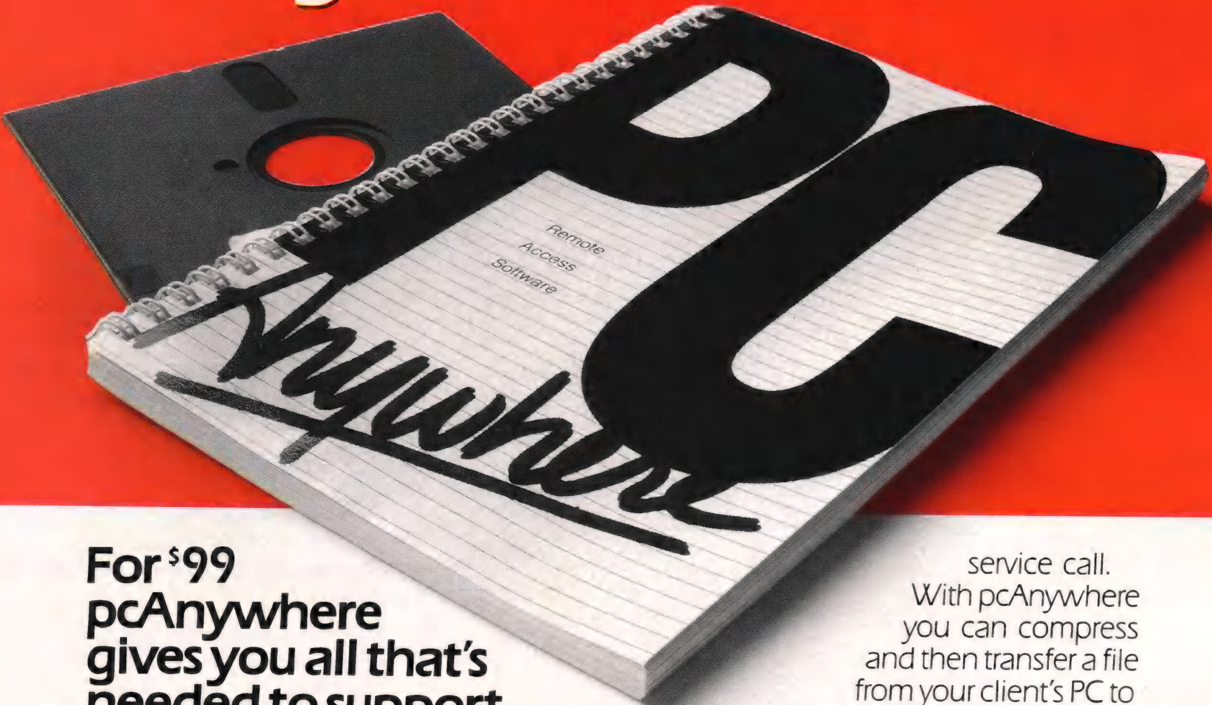

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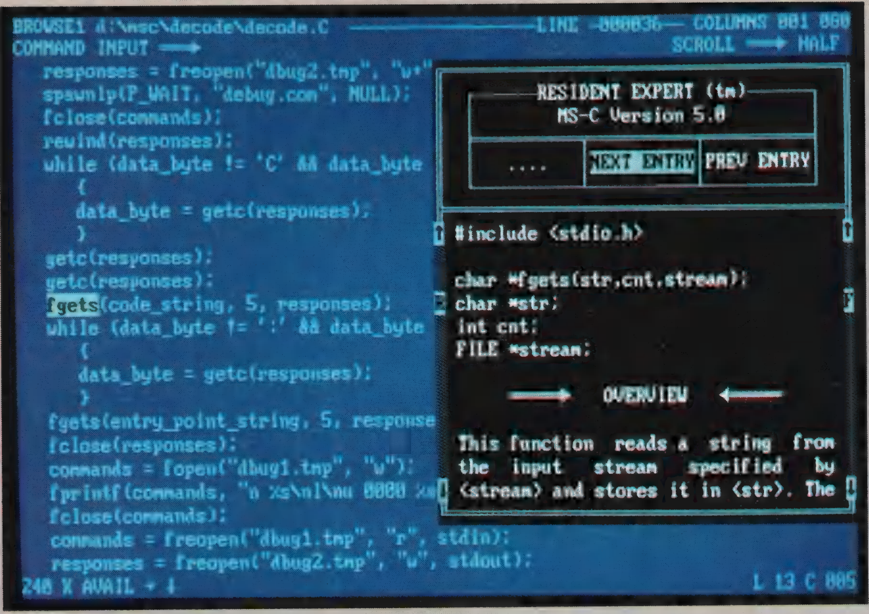

```
BROWSE1 d:\msc\decode\decode.C ——————————LINE -000036— COLUMNS 001 080
COMMAND INPUT ——→                                        SCROLL ——→ HALF
   responses = freopen("dbug2.tmp", "w+"
   spawnlp(P_WAIT, "debug.com", NULL);
   fclose(commands);
   rewind(responses);
   while (data_byte != 'C' && data_byte
      {
      data_byte = getc(responses);
      }
   getc(responses);
   getc(responses);
   fgets(code_string, 5, responses);
   while (data_byte != ':' && data_byte
      {
      data_byte = getc(responses);
      }
   fgets(entry_point_string, 5, response
   fclose(responses);
   commands = fopen("dbug1.tmp", "w");
   fprintf(commands, "n %s\nl\nu 0000 %
   fclose(commands);
   commands = freopen("dbug1.tmp", "r", stdin);
   responses = freopen("dbug2.tmp", "w", stdout);
240 K AVAIL + ↓                                                   L 13 C 005
```

```
RESIDENT EXPERT (tm)
MS-C Version 5.0

#include <stdio.h>

char *fgets(str,cnt,stream);
char *str;
int cnt;
FILE *stream;

This function reads a string from
the input stream specified by
<stream> and stores it in <str>. The
```

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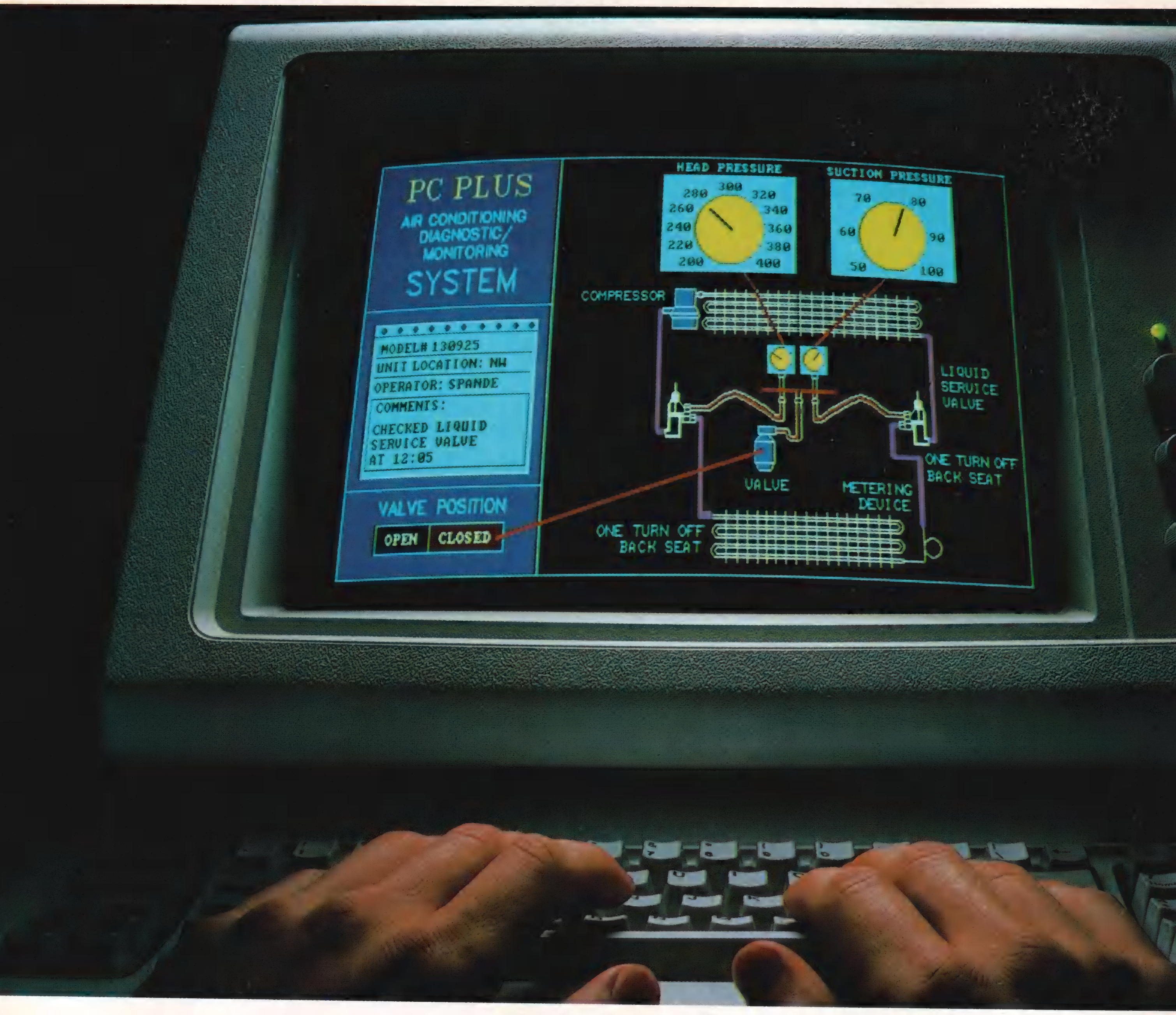

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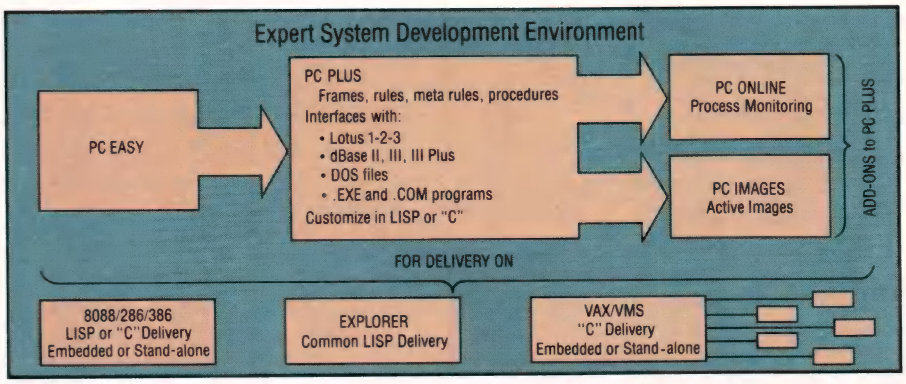

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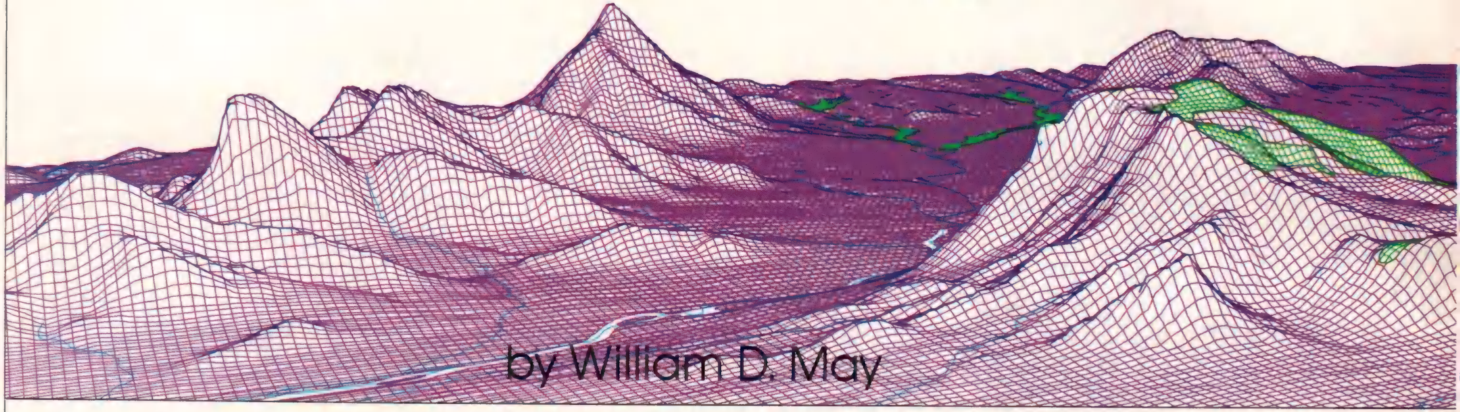
TEXAS INSTRUMENTS

3-D Images from Contour Maps



This contour-analysis algorithm vividly demonstrates the gulf between human cognition and an algorithmic procedure.

Contour maps have intrigued me ever since my introduction to them in high-school geology. By studying a contour map, I could learn about inaccessible parts of the world and discover unexpected possibilities in my backyard. Yet for all its wealth of information and detail, a contour map is less than intuitive. You must say to yourself, "these contours are very close together, so this area must be very steep," or "these contours are widely spaced, so this area is fairly level."

It would be wonderful to be able to feed a contour map into a machine that could project images of the terrain in three dimensions. Then you could rotate the view, zoom in on interesting spots, change to different viewpoints, and generally get an extremely tangible feeling for the characteristics of the landscape.

This article is about a set of algorithms that takes a step toward achieving these objectives. The algorithms analyze a binary image of a contour map (such as that produced by an image scanner) and produce a representation of the image that can be used by a hidden-line algorithm. The hidden-line algorithm can then produce 3-D views from any mathematically valid viewpoint. Figures 1 and 2, page 20, show the before and after of this transformation.

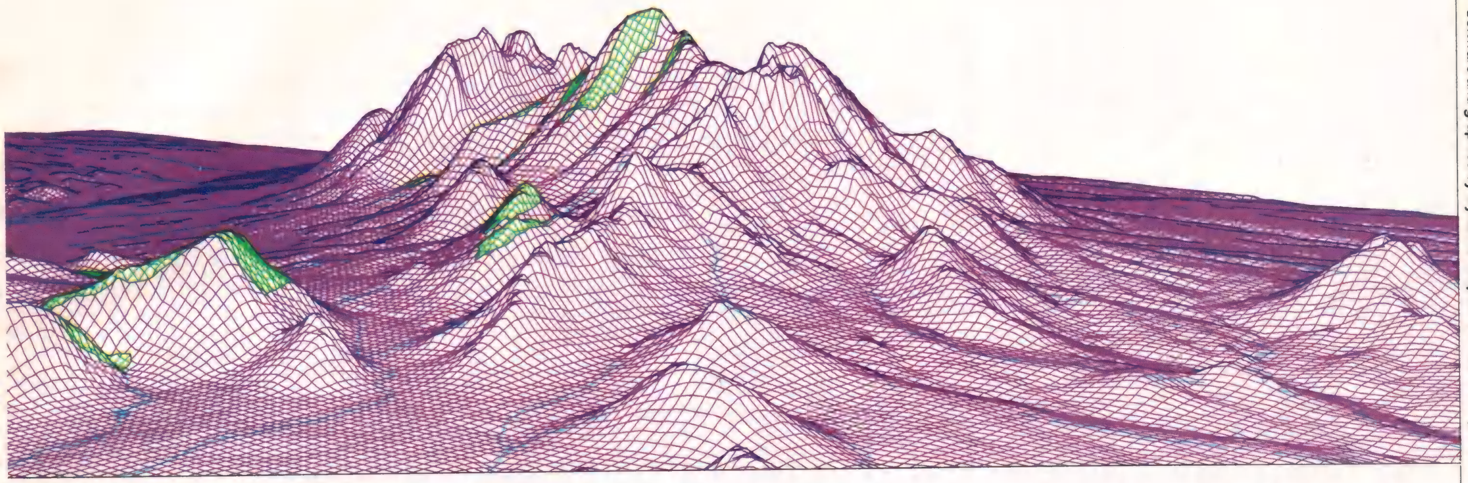
In many respects the means of transforming the contour map into three dimensions is as interesting as the transformation itself. Seeing the contours on a contour map is trivial for the human eye and brain but complex for a computer. A large part of the problem stems from bandwidth: the eye/brain seems to see an entire image, its components, and the relationships among its components simultaneously, but the computer "sees" an image one pixel at a time. The low bandwidth of the computer's vision makes it extremely difficult for the computer (that is, its programmer) to identify objects and to perceive their relationships.

The approach I have taken uses some geometry to overcome this lack of cognitive ability, first to find and identify the contours in the image and then to analyze the contour relationships (nesting). The drawback of using a geometric solution (as opposed to an "intelligent" or "learning" solution) is that this approach is useful only for this particular application. But I think this drawback is more than offset by the ability to do something that the eye/brain cannot: use the analysis to build a 3-D image from a 2-D map.

Of course, contour representation is used in areas other than geography, such as medicine, chemistry, and astronomy. The contour-analysis algorithm I have developed can be used in these situations as well, although the interpretation of the resulting "image" will be quite different.

I should caution you that the current state of this algorithm falls somewhat short of my original objective, the major problem being with the input of the map. The algorithm needs an image that consists of topologically correct contours. This means that continuous, closed contours on the map must in fact be continuous and closed in the image and that contours don't cross or merge.

William D. May, 20A-M23, Arthur D. Little Inc., Acorn Pk., Cambridge, MA 02140. Bill is a consultant specializing in system development.



Software and graphics by Dynamic Graphics, Inc., Berkeley, CA.

In real life, such as using a U.S. Geological Survey map, this requires that extraneous information be filtered out of the image and that the contours themselves get scanned accurately. Both requirements are difficult to achieve. U.S. Geological Survey maps contain a wealth of symbols, lines, markings, grids, shadings, and so on that interfere with the filtering process. The requirement for continuous lines is also difficult to achieve. First, the maps often place elevation information directly on the contour line, which is easy for humans to read but difficult for computers to interpret. Second, scanners have difficulty accurately placing the very fine lines used for contours, so the result sometimes looks more like a fog of dots where the contour is supposed to be than a continuous line.

From the Map to Three Dimensions

A program that transforms contour maps into 3-D views requires several steps to achieve its objective. I have summarized these steps below. The process draws on diverse subjects, such as image processing and 3-D graphics. The focus of this article is mainly on the algorithms for analyzing contour map information and building a 3-D representation from the analysis. These tasks correspond to steps 3 through 5 below.

1. Getting the map image into the computer. I use images stored in Macintosh MacPaint format, which can be created using MacPaint or via scanners such as Thunderscan. The MacPaint format is simple, consisting of 512 bytes of header information (which is usually ignored) and a bit map in which each bit represents a single black or white pixel in the image. Apple's Macintosh Tech Note #86 explains the MacPaint format in detail and provides sample Pascal code for reading and writing MacPaint documents.
2. Cleaning up the image. Extraneous image data —that is, data that is not part of a contour—must be removed before trying to analyze the map. In many cases some human work is needed to overcome imperfections in the scanning process.
3. Analyzing the contour image. This refers to finding all the contours in the bit map, "remembering" which are nested in which, and storing them in a way that can be used to build a 3-D image. The contour-analysis algorithm builds two data structures during the analysis. One is an array with one entry for each contour discovered in the map. Each array element contains the coordinates of one point on the contour; the index of the enclosing contour; and, eventually, the contour's elevation. The algorithm also stores every point that is on a contour as a node in a tree. The key for the node is the point's coordinates, and the datum consists of the array index of the contour the point is on. These two data structures make it easy to access the contours directly or to access contour information when given any point on the contour. This in turn makes the translation into three dimensions easy.
4. Assigning elevations to the contours. A restriction of the contour-analysis algorithm is that it cannot read elevations directly from a digitized image. In some applications this does not matter; in others, such as U.S. Geological Survey maps, the ability would be quite useful. That would be a different and very large project, though, and leaving it out, as I have done here, does not affect the basic logic of the algorithm. In lieu of reading the elevations from the map, I have implemented the simple case in which all nested regions are assumed to be ascending. Given the base elevation of the map, the program simply increments the elevation for each level of nesting in the image. The more general solution would allow users to override elevation assignments manually.
5. Creating an internal 3-D representation of the terrain.

(continued from page 19)

After the contour analysis, the program builds a rectangular grid as the transformed representation of the contour map. The grid is simply an array in which each cell contains the elevation at a point on the map. The larger the grid, the more finely it covers the map and the greater the detail in the resulting image.

6. Displaying a projection of the grid. The final step is to use a hidden-line algorithm to display the grid as a 3-D projection on the screen. Hidden-line algorithms allow the viewer to observe the scene from any angle in a fairly realistic format.

How the Contour Analysis Works

Two problems must be solved in order to analyze a contour map. The algorithm must find all the contours, and it must determine their nesting relationships.

The contour search begins by using a 2-D search of the image—that is, starting at the top left and scanning across each row until it finally reaches the bottom right. Each time it finds a contour (a black pixel), it determines if it is a contour that was previously "seen." If not—that is, if the program has found a new contour—it adds the contour to its internal data structures. In either case the search continues.

Unfortunately, this search pattern is too simple to fully serve your needs. The problem is that it provides no easy way to track how contours are nested. In order to track the nesting relationships you must specify a contour and have the contour-analysis algorithm find a single level of contours within it, as shown in Figure 3, below. The interiors of the contours within the region should not be searched (yet). This procedure makes the tracking of nesting easy: the enclosing contour is the "parent" of the contours discovered within it. Assuming you have this ability, you then use the top-left to bottom-right search to find the lowest level of contours in the image and use your new search algorithm to

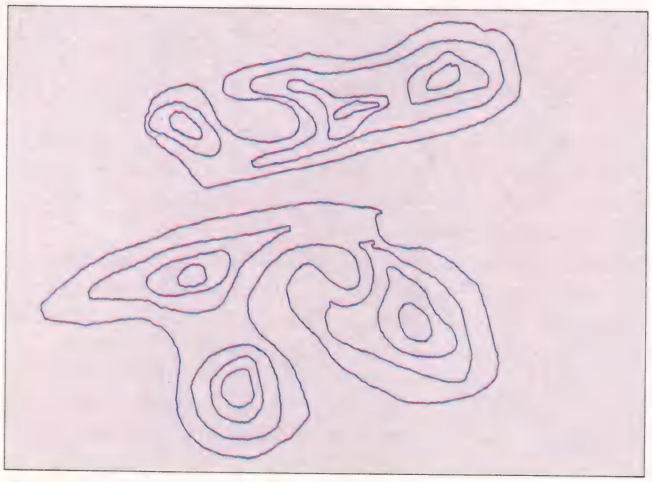


Figure 1: *A sample contour map*

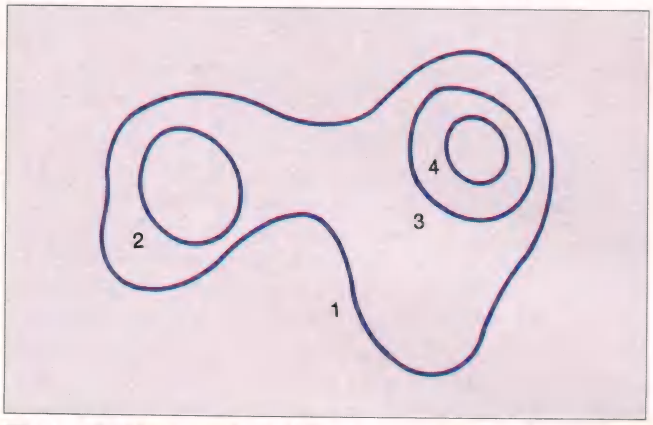


Figure 3: *The search within contour 1 will find contours 2 and 3 but not 4. Contour 4 will be found by a search of contour 3.*

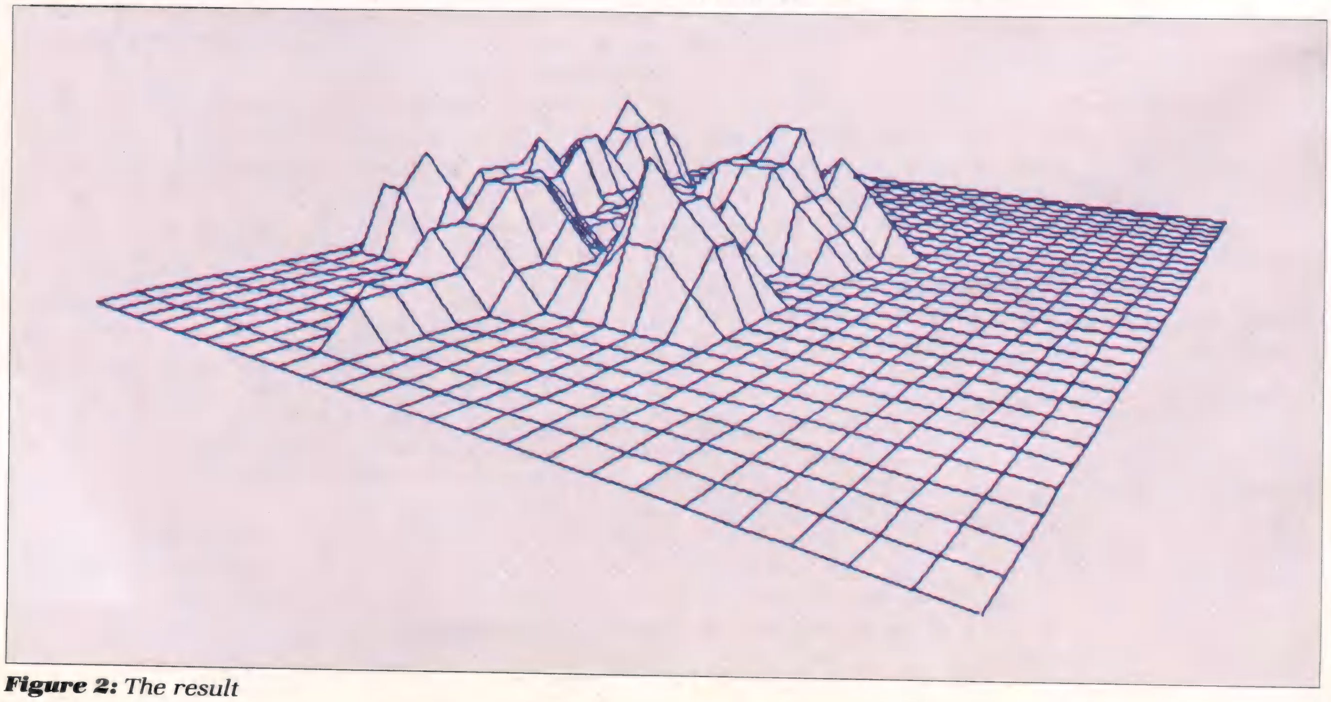


Figure 2: *The result*

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(continued from page 20)

search the interior of each of the newly discovered contours (and then use it again to search the interior of any contours within them, and so on . . .).

This new search hinges on being able to differentiate the interior or exterior of an enclosed region. This requires a simple observation: if the program is following a contour in a counterclockwise direction, and it is currently following a downward arc, then the interior lies to the right of the current position, as seen in Figure 4, below. Alternatively, if the program is following a contour in a clockwise direction, and it is currently on a downward arc, then the exterior lies to the right of the current point.

Using this observation, the sequence of events to search the interior of a region is this: Trace around the bounding contour in a counterclockwise direction, and at each point on a downward arc, scan to the right (that is, the interior) until you find a new contour or find the other side of the bounding contour. On finding a new curve, traverse this curve in a clockwise direction, still scanning to the right on a downward arc, as indicated in Figure 5, below. Because the traversal is now reversed, this scan will now be the exterior of the new contour—that is, the interior of the original contour but on the opposite side of the nested contour. Applied to the bounding curve and all the interior curves, this procedure scans the interior of the bounding contour but not the interior of any contours nested within the bounding contour. For example, in Figure 3 a search of contour 1 done in this way will encounter contours 2 and 3 but not contour 4. Contour 4 will be discovered only when a search is made of the interior of contour 3. In fact, the entire search is reduced to this process by treating the border of the image itself as a large contour.

Following the contour analysis, the elevation assignments are made by stepping through an array of the contours found and assigning an elevation equal to the enclosing contour's elevation plus the elevation increment. This is where I use the assumption that all nested regions are rising.

Finally, an array of elevations is developed to be used as input to the hidden-line algorithm. The array elements are calculated by traversing the image along the grid lines. When a traversal begins, it sets its current elevation to the base elevation of the contour map, and each time it reaches a grid intersection it assigns the current elevation to the corresponding element of the array. The traversal also looks for intersections with contours on the map. These intersections signal a change in the current elevation. When it encounters a contour, the program first retrieves the elevation of the contour from the contour array described earlier.

At first glance it may seem that this new elevation should become the current elevation. It's not that simple. If the traversal is going into a nested region, then the new elevation is the elevation of the region it is now entering and thus should become the current elevation. If the traversal is leaving a nested region, however, the new elevation is the elevation of the region just left.

For example, imagine traversing the following simple map: the base of the map has a zero elevation, and there is a plateau in the center with an elevation of 100 feet. When the traversal begins, it uses the base elevation (0) as the current elevation. When it encounters the contour around the plateau, because it is entering a nested region, it assigns 100 to the current elevation. When it reaches the other side of the plateau, it once again meets the contour with an elevation of 100. Because you are now leaving a nested region, however, this signals that the elevation is no longer 100 feet, and, in this case, it should now be the base elevation of 0.

There is a data structure that naturally resolves this problem: the stack. Each time the program encounters a contour, it compares the contour's elevation to the top of the stack. If the elevation is different, it pushes the new elevation. If the new elevation is the same as the top of the stack, it pops the stack. In either case the current elevation is the number on the top of the stack.

Using the Program

Using the program is quite simple. The main program sets up a contour array (it must be larger than the expected number of contours) and a pointer to the tree of points as global variables. It then calls *find_all_contours( )*, passing a pointer to the bit map to be analyzed. On return it calls *make_hidlinpix( )* to assign elevations, which in turn calls *make_grid( )* to calculate the grid

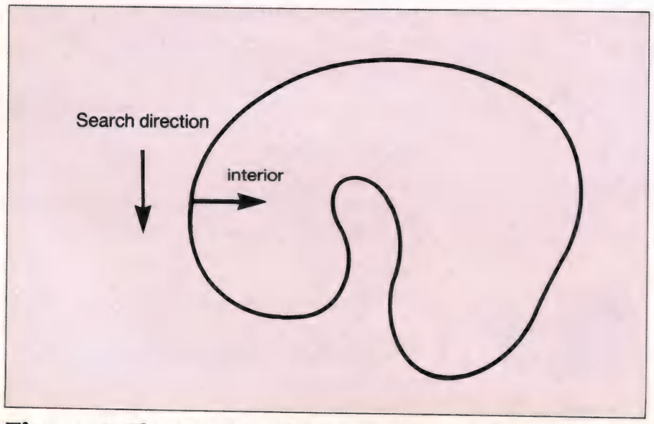

Figure 4: *The interior of the region is to be right when traversing a descending arc.*

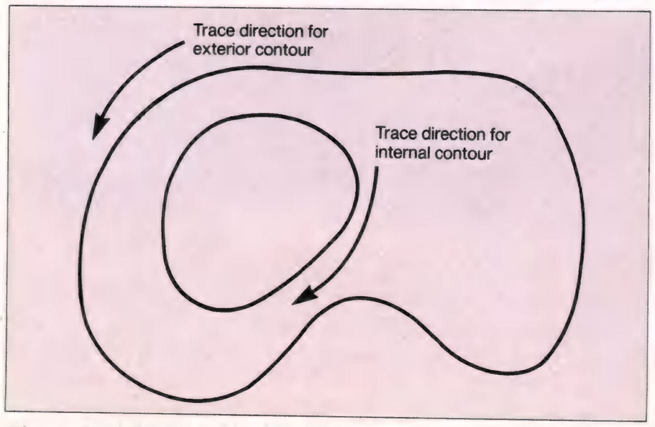
Trace direction for exterior contour
Trace direction for internal contour

Figure 5: *The trace for the external curve is counterclockwise; for internal curves it is clockwise.*

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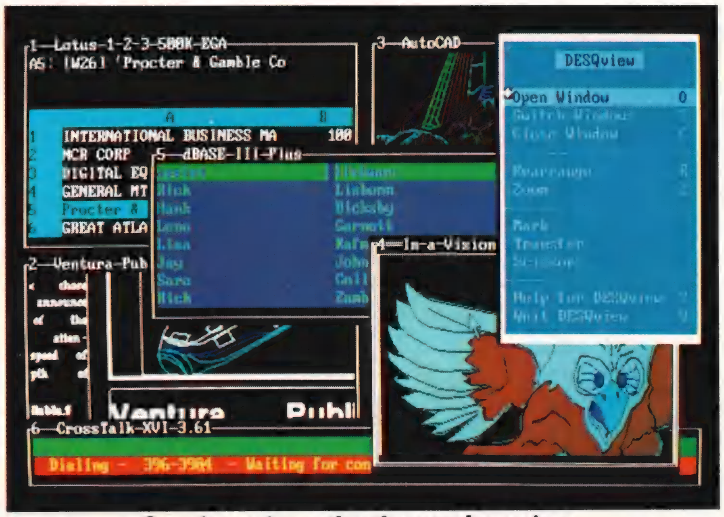

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(continued from page 22)

elevations. The current implementation converts the grid to a disk file that is then used as input to a hidden-line algorithm.

The previous quick overview of the contour-analysis and grid-construction algorithms glosses over most of the gory details, such as coordinating progress and tracing curves. I'll now describe these in more detail.

Find_all_contours( )

Find_all_contours( ), as its name implies, is responsible for coordinating the entire contour search. The progress of the contour-analysis algorithm is based on a queue (a first-in/first-out data structure). The queue is *find_all_contours( )*'s means of communicating with the lower-level function *find_contours( )*. *Find_all_contours( )* calls a function to enqueue the points on a contour of interest and then calls *find_contours( )*. *Find_contours( )* then dequeues all points, and those on a descending arc are used as the starting points for rightward scans.

The queue is built by tracing contours in a counterclockwise direction and includes the location of each point on the contour as well as a chain code for the point. The chain code is an integer from 0 to 7 that indicates the direction moved from the previous contour point to the current contour point, as shown in Figure 6, below. Thus a chain code of 0 indicates a movement to the right, 2 is a movement up, 4 is to the left, and 6 is down. *Find_all_contours( )* initiates the entire contour analysis by enqueuing the borders of the image—that is, by treating the border of the image as a contour itself. Because only the left-hand side of the image will have chain codes in the range 5 to 7, only the left side really needs to be enqueued. *Find_all_contours( )* then calls *find_contours( )*, which in turn uses the queue to do a single-level contour search. Any contours found by *find_contours( )* are placed in the contours array.

On return from *find_contours( )*, there will usually be some contours stored in the contour array. *Find_all_contours( )* then steps through each unsearched contour in the array. At each iteration, *find_all_contours( )* calls a function to enqueue (by tracing) the points on the contour and once again calls *find_contours( )* to search the interior of the new region. When the interiors of all contours in the array have been scanned, the search is complete.

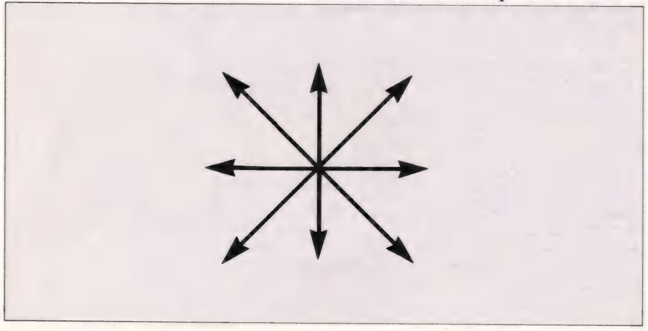
Figure 6: *Chain codes*

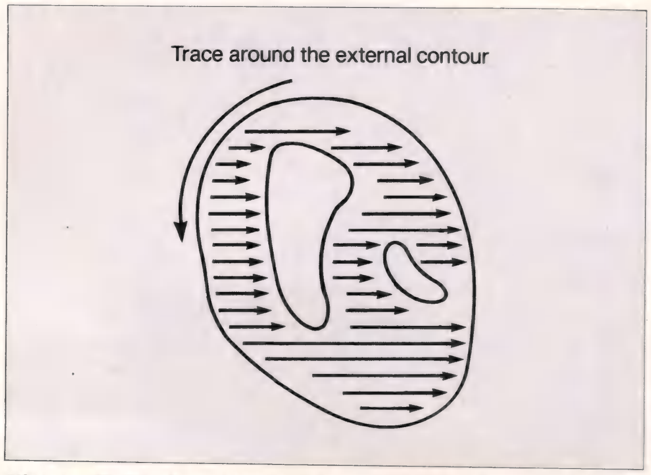

Figure 7: Find_contours( ) *searches the interor of a given contour for nested contours.*

Find_contours( )

Find_contours( ) is responsible for finding a single level of contours nested within a given region, which is that region enqueued by *find_all_contours( )* (see Figure 7, below). Because the queue was created by tracing the contour in a counterclockwise direction, the contour interior will be found by scanning to the right of points whose chain codes are in the range 5 to 7. For each chain code in this range, the function *search_x( )* is used to perform the actual scan of the bit map.

The scan can return either of two results: it can encounter a known contour (which can be the other side of the enclosing contour, the edge of the bit map, or an internal but previously discovered contour), or it can find a new contour. If it finds a new contour, then *find_contours( )* calls *trace( )* to traverse the new contour in a clockwise direction. Once again the trace enqueues the points on the contour. When *find_contours( )* reaches these points in the queue, it will result in the scan starting on the right side of the new contour and still moving right. The result is that the interior of the enclosing contour is scanned, except for the interiors of any nested contours.

There are two problems with this general procedure: tabletops and peaks (see Figure 8, below, for examples). Tabletops are horizontal runs to the right. The problem is that the point on the downward arc will start the scan. The scan will immediately encounter a point on the contour (that is, part of the tabletop) and stop, thinking (incorrectly) that it has reached the other side. The solution to this problem is to look at the next chain code as well as the current one. If the current chain

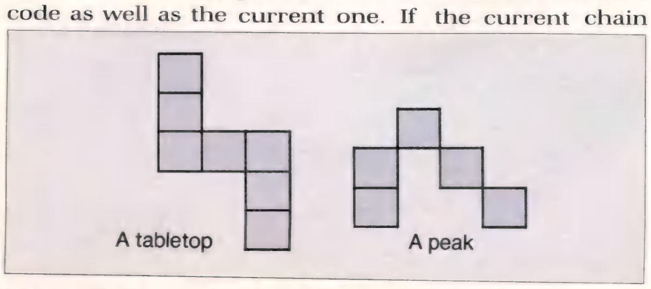

Figure 8: *Examples of a tabletop and a peak*

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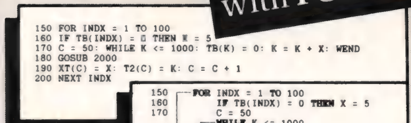
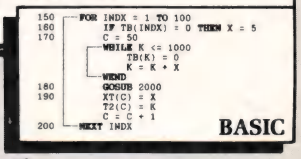


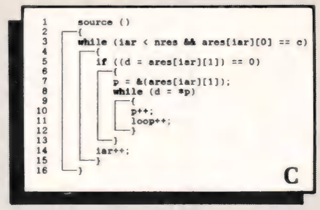
```
150 FOR INDX = 1 TO 100
160 IF TB(INDX) = 0 THEN X = 5
170 C = 50: WHILE K <= 1000: TB(K) = 0: K = K + X: WEND
180 GOSUB 2000
190 XT(C) = X: T2(C) = K: C = C + 1
200 NEXT INDX
```

Before

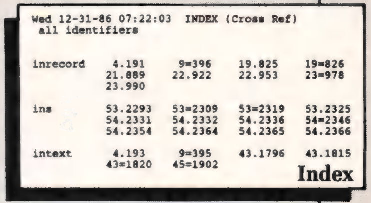


```
150  ┌──FOR INDX = 1 TO 100
160  │       IF TB(INDX) = 0 THEN X = 5
170  │       C = 50
     │  ┌────WHILE K <= 1000
     │  │         TB(K) = 0
     │  │         K = K + X
     │  └────WEND
180  │       GOSUB 2000
190  │       XT(C) = X
     │       T2(C) = K
     │       C = C + 1
200  └──NEXT INDX
```

After



```
      source ()
  ┌───{
  │   while (iar < nres && ares[iar][0] == c)
  │  ┌───{
  │  │   if ((d = ares[iar][1]) == 0)
  │  │  ┌───{
  │  │  │   p = &(ares[iar][1]);
  │  │  │   while (d = *p)
  │  │  │  ┌───{
  │  │  │  │   p++;
  │  │  │  │   loop++;
  │  │  │  └───}
  │  │  └───}
  │  │   iar++;
  │  └───}
  └───}
```



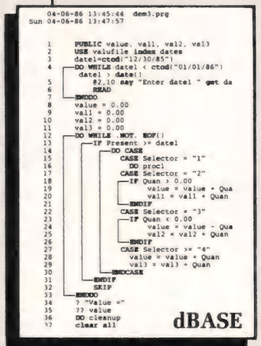
```
Wed 12-31-86 07:22:03  INDEX (Cross Ref)
 all identifiers

inrecord      4.191      9=396     19.825     19=826
             21.889     22.922     22.953     23=978
             23.990

ins         53.2293    53=2309    53=2319    53.2325
            54.2331    54.2332    54.2336    54=2346
            54.2354    54.2364    54.2365    54.2366

intext        4.193      9=395    43.1796    43.1815
            43=1820    45=1902
```

$97.00



```
    04-06-86 13:45:44  dem3.prg
Sun 04-06-86 13:47:57

      PUBLIC value, val1, val2, val3
      USE valufile index dates
      datel=ctod("12/30/85")
   ┌──DO WHILE datel < ctod("01/01/86")
   │   datel > date()
   │      @2,10 say "Enter datel " get da
   │      READ
   └──ENDDO
      value = 0.00
      val1 = 0.00
      val2 = 0.00
      val3 = 0.00
   ┌──DO WHILE .NOT. EOF()
   │  ┌──IF Present >= datel
   │  │  ┌──DO CASE
   │  │  │    CASE Selector = "1"
   │  │  │      DO proc1
   │  │  │    CASE Selector = "2"
   │  │  │   ┌──IF Quan > 0.00
   │  │  │   │       value = value + Qua
   │  │  │   │       val1 = val1 + Quan
   │  │  │   └──ENDIF
   │  │  │    CASE Selector = "3"
   │  │  │   ┌──IF Quan < 0.00
   │  │  │   │       value = value - Qua
   │  │  │   │       val2 = val2 + Quan
   │  │  │   └──ENDIF
   │  │  │    CASE Selector >= "4"
   │  │  │      value = value + Quan
   │  │  │      val3 = val3 + Quan
   │  │  └──ENDCASE
   │  └──ENDIF
   │      SKIP
   └──ENDDO
      ? "Value ="
      ?? value
      DO cleanup
      clear all
```

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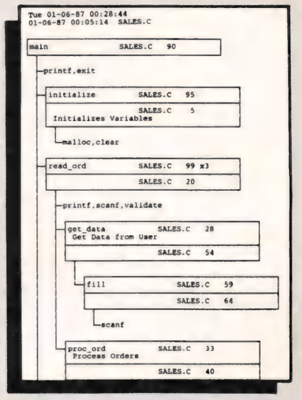

```
Tue 01-06-87 00:28:44
01-06-87 00:05:14  SALES.C

main                    SALES.C   90
 │
 ├─printf,exit
 │
 ├─initialize           SALES.C   95
 │                      SALES.C    5
 │   Initializes Variables
 │   └─malloc,clear
 │
 ├─read_ord             SALES.C   99 x3
 │                      SALES.C   20
 │   ├─printf,scanf,validate
 │   │
 │   ├─get_data             SALES.C   28
 │   │   Get Data from User
 │   │                      SALES.C   54
 │   │   └─fill                 SALES.C   59
 │   │                          SALES.C   64
 │   │       └─scanf
 │   │
 │   ├─proc_ord             SALES.C   33
 │   │   Process Orders
 │   │                      SALES.C   40
```

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CIRCLE 350 ON READER SERVICE CARD

(continued from page 24)

code was 0 and the next chain code is 5–7, then the program has just reached the end of a tabletop and it should start to do a scan.

A peak is a single pixel at the top of a contour. Peaks present another problem: they are never on a downward arc and will never initiate a rightward scan. A peak can result in at most a single scan line being skipped. Thus, in the worst case, the only contour that can be missed is a single line of pixels. Because this is a degenerate case, I did not feel it needed to be resolved.

Search_x( )

Search_x( ) scans to the right of a given point until it finds a black pixel or reaches the edge of the bit map, as shown in Figure 9, below. It then returns a value of 1 if the pixel is on a new contour or 2 if it is either on a known contour or at the edge of the bit map. A pixel has been seen before if it can be found in a tree containing the pixels lying on contours.

The interrogation of individual pixels on an off-screen, bit-map image can be done in several ways. The Macintosh Toolbox contains the functions *GetPixel( )* and *GetCPixel( )* (in the Macintosh II's Color QuickDraw). However, I have used an assembly-language function, called *getpixel( )*, that accomplishes the same task by accessing the bit map directly. This *getpixel( )* is quite fast, but it lacks the flexibility and generality of its Toolbox counterparts. Any machine that supports bit-

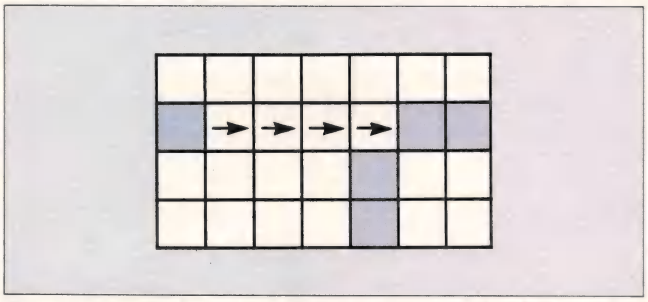

Figure 9: Search_x( ) *starts at a given pixel and searches to the right until it hits a contour or the edge of the image.*

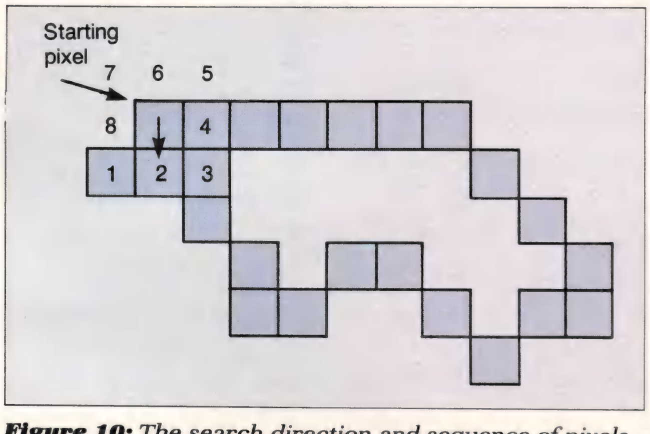

Figure 10: *The search direction and sequence of pixels searched during a contour trace ensures that the trace always follows the outermost border of the contour.*

mapped graphics will have counterparts to *getpixel( )* or *GetPixel( )* (the Microsoft C, Version 5.0, library now has a *_getpixel( )* function).

Trace( )

Trace( ) is the real workhorse of the contour-analysis algorithm. It traces a given curve in a clockwise or counterclockwise direction, and it simultaneously updates both the queue and a tree of points lying on the contour.

In order to follow a contour, *trace( )* uses the chain codes described earlier. An example can help explain the process. Assume that the program will traverse a contour counterclockwise. The calling function passes a point on the exterior of the contour to *trace( )*. First, the trace sets the initial search direction to 6 (down). It then looks at pixels with chain codes 5, 6, and 7 from the starting point—that is, "search direction–1," "search direction," "search direction + 1," all modulo 8 (see Figure 10, below). Note that the search starts the furthest to the exterior as is possible (a pixel at chain code 4 would mean that the starting pixel is not on the exterior).

The first hit then becomes the new search direction. If there is no hit at all, trace adds 2 to the search direction (modulo 8) and tries again. This process continues for three iterations at most, to prevent an infinite loop if the contour consists of a single point.

Note that if there is a break in the contour, this algorithm will circle around the end point and return back to the starting point. Also note that *trace( )* always proceeds around the exterior of a contour. If the contour is more than one pixel thick, *trace( )* will ignore the interior pixels. These points will be found later while scanning the interior of the region.

Building the 3-D Image

As indicated in the overview, the contour analysis itself is only the first step in producing a projection of the contour map. Once the analysis is complete, it must be converted into a form that a hidden-line algorithm can use as input. For purposes of demonstrating the contour analysis, I have used an algorithm published by L. Ammeraal in *Programming Principles in Computer Graphics*. This requires two further steps after the analysis itself.

First, the data from the analysis must be used to construct a 2-D array, with the value of each element of the array being the elevation at that point. This is done by the function *make_grid( )*, as described in the overview.

Next, the array itself must be converted into a file that can be used as input to the hidden-line algorithm. This is done by the function *make_hidlinpix( )*. A small section of this output file is shown in Table 1, page 28. It starts with the coordinates of the midpoint of the object to be drawn. Then follows a section that lists all the points in the array and their spatial coordinates (x, y, z). Thus point 1 is at spatial coordinates (0.0, 0.0, 0.0), 33 is at (0.0, 1.0, 0.0), and so on.

The key to the hidden-line algorithm is the following section, beginning with the word *Faces:*. This is a decomposition of the grid into triangular faces. Trian-

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(continued from page 26)

gles are used because all points on a triangle in 3-D space are located on the same plane (see Ammeraal's book for further explanation). Each face is defined by its three corner points listed in counterclockwise order: for example, the file shown here indicates that points 1, 34, and 2 form a triangular face. The points 1, 2, 33, and 34 form the corners of a rectangle. The program has broken this rectangle into two triangular faces: 1, 34, and 2; and 1, 33, and 34. The minus sign for point 34 indicates that the line segment from point 1 to point 34 should not actually be drawn, in this case because it forms a diagonal across a rectangle.

In fact, the grid faces are actually defined twice in the file: once as the top side (the normal viewpoint) and once as the under side; that's the reason for the apparent redundancy in the description of the faces. This technique allows you to view the grid both from above and below (underground if this were a topographic map!). This file is then read and processed by the program hidlinpix. The result is shown in Figure 2.

Portability and Optimization

The contour-analysis algorithm was written and tested on a 512K Macintosh and on a Macintosh II using Lightspeed C. In order to simplify the development and testing process, I modified a copy of the Lightspeed *stdio* library so that the console window opens to cover the lower quarter of the screen (instead of the entire desktop, as it normally does). The program then opens two windows: a window that shows the source image and a window that displays the progress of the contour analysis (a sort of debugging animation). The algorithms themselves are intended to be portable, but I have not actually tested the code in other environments, so there could be surprises in store.

I have used the Macintosh's graphics abilities to animate the code, so if you find the written explanation of the program complex, and if you are able to view the animation, you may find that it makes visual sense. There is some redundancy because of the need to trace each contour twice (once when first discovered, once again to search its interior), but the vast majority of points in the image are visited only once.

The code shown here uses one important optimization: the avoidance of the memory-management library supplied with Lightspeed C (that is, it avoids the use of *malloc( )*, *free( )*, and so on). Instead, I have used a nonstandard function called *getmem( )*. The rationale for this action is explained in detail in the source code to *getmem( )* itself. I was reluctant to include *getmem( )* with this article (it lacks its counterparts, such as *freemem( )*), but the speed improvement is quite dramatic; without *getmem( )* the program is slow, even on the Macintosh II.

```
           15.500000   12.500000    0.000000
  1         0.000000    0.000000    0.000000
  33        0.000000    1.000000    0.000000
  65        0.000000    2.000000    0.000000
  97        0.000000    3.000000    0.000000
  129       0.000000    4.000000    0.000000
  161       0.000000    5.000000    0.000000
  193       0.000000    6.000000    0.000000

  . . .

  Faces:

  1     -34    2#
  2      34   -1#
  1     -34   33#
  33     34   -1#
  33    -66   34#
  34     66  -33#

  . . .
```

Table 1: *A sample of the output file from the contour analysis*

Miscellaneous Functions

The contour analysis depends on several different data structures. I have avoided reinventing the wheel by using previously published code, particularly from some of Allen Holub's columns in *DDJ*. These borrowings include the queue and AVL tree code published in June 1985 and August 1986, respectively.

Conclusion

For the eye and brain, identifying objects and relationships in the visual world seems effortless. The contour map analysis algorithm is an example of the complexity of this process when performed by machine, even when restricted to a simple class of images. The algorithm vividly demonstrates the wide gulf between human cognition and an algorithmic procedure. In spite of the constraints placed on it, though, the machine is able to provide services that are impossible for the eye/brain; specifically, restoring a 3-D image from a 2-D representation.

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415) 366-3600, ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro).

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(Listings begin on page 66.)

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A Graphics Toolbox for Turbo C

by Kent Porter

The first article in a two-part series on designing a library for PC graphics

That Borland's Turbo C comes equipped with 350 functions and macros is pretty impressive, until you realize that not one of them has anything to do with graphics. To fill this void I've constructed my own version of a graphics toolkit for Turbo C.

To make the information more easily digestible, I've divided the project into two bite-size articles. This piece introduces a basic library of graphics calls and shows how to put them to work in pixel-oriented graphics; Part 2 (to appear in December's *DDJ*) will combine this graphics library with data structures and C functions to control pop-down menus, dialog boxes, and other appearance features that users have come to expect in contemporary software.

The MS-DOS Underpinning

IBM PCs, or equivalents, rely on ROM BIOS interrupt *10h* (16 decimal) for their graphics capabilities. This interrupt furnishes "generalized" functions for various aspects of text and APA (all-points addressable, or pixel-oriented) graphics. I say "generalized" because the ROM BIOS accommodates numerous modes, some of which may not be available on certain hardware configurations. For example, the ROM BIOS handles video modes for the EGA monitor and the PCjr that don't exist when a CGA or monochrome adaptor is present in the system.

There are 16 core functions in the ROM BIOS video services. These functions govern display aspects such as the position or shape of the cursor, the video mode (text and APA options), the active display page, character output, pixel graphics, and others.

The ROM BIOS functions are not known for their speed. In general, they're adequate in text operations but less than adequate in APA graphics. You could devise much faster pixel manipulations by writing to the display memory directly, and indeed, many commercial packages do just that. The speed advantages of this approach, however, are obtained with a high risk of incompatibility: environments such as Windows and OS/2 are much more intolerant of direct display memory access.

In selecting the ROM BIOS tradeoff rather than directly writing to screen memory, I've deliberately opted for the more conservative approach on two grounds: first, the ROM BIOS calls are the approved method for doing graphics and future machines will probably support them within the definition of "well-behaved"; and second, faster processors will cancel out their slower speed, resulting in a zero loss/gain from the user's perspective. While this is an arguable position, and no doubt some readers will dispute it, at least you know my underlying assumptions. Now let's see how to access those ROM BIOS functions.

ROM BIOS Calls from Turbo C

Like DOS itself, the ROM BIOS routines under interrupt *10h* expect a function code in register *AH*, with other parameters passed as required by specific functions in the rest of the registers. Any number of Microsoft, IBM, and commercial publications document the ROM BIOS calls; for this project I referred to Ray Duncan's indispensable *Advanced MS-DOS* (pages 399–420).

ROM BIOS calls are made using the Turbo C *int86( )* function. Registers are set up in a structured variable bound to the *REGS* union as defined in Turbo C's DOS.H header file.

The *REGS* union includes all the general registers of the 80x86 line of processors and furnishes a notation convention for byte (8-bit) and word (16-bit pair) registers. For example, if you declare the structured variable as *union REGS r;* you can load the value *0Ch* into byte register *AH* with *r.h.ah=0x0C;* and the same value into word register *BX* with *r.x.bx=0x0C;*. The structure notation *.h.* indicates a byte register, and notation *.x.* indicates a word register. The *REGS* union encompasses all byte registers (*AH–DL*) and all word registers (*AX–DX*) as well as *SI*, *DI*, and the flags. It does not include the segment registers (*CS*, *DS*, *ES*, and *SS*), which are irrelevant to ROM BIOS calls.

To call a ROM BIOS video service

Kent Porter, 1909-4 Montecito Rd., Mountain View, CA 94043. Kent has written 17 books about programming and hundreds of magazine articles on computer hardware and software. He is a technical editor for DDJ.

routine, you place the function code in *r.h.ah* and the required parameters in other registers and execute the Turbo C *int86( )* function *int86 (0x10, &r, &r);*.

Function *int86( )* performs the following:

- saves the caller's registers
- loads the CPU registers from the union whose address is passed in the second argument
- executes the interrupt given in the first argument
- on return from the ROM BIOS, places register contents in the union passed as the second address argument (the same as the first address argument in this example)
- restores the caller's registers
- resumes execution in the calling program

On resumption you can pluck any BIOS-returned value from the variable bound to the *REGS* union—*r* in the examples shown here—by using the appropriate register-type notation.

For example, suppose you want to determine the current cursor position in video page 0. The setup is:

```
r.h.ah = 0x03; /* read position */
r.h.bh = 0; /* in page 0 */
int86 (0x10, &r, &r); /* call BIOS */
```

Afterward you can fetch the row with *cursRow=r.h.dh;* and the column with *cursCol=r.h.dl;*. This is the same as, but easier than, performing an equivalent call in assembly language. An added benefit is that the structured variable bound to the *REGS* union retains the returned register values for as long as it exists or until the next call to the ROM BIOS routines. Thus, you can fetch the returned register values at your convenience. You can translate these ROM BIOS calls into C functions.

Syntactic Sugar

Many of Turbo C's 350 functions and macros are simply DOS and ROM BIOS calls sugar-coated to look like C. In the same spirit, you can pack a little sugar around the ROM BIOS video service routines and call them "a basic library of Turbo C graphics functions."

Listing One, page 82, shows an *#include* file, VIDEO.I, which contains the fundamental 16 ROM BIOS calls plus a couple of extended functions that synthesize several calls. Any program that has to perform graphics operations can obtain the full set of functions with the simple statement *#include <video.i>* calling whichever specific ones it needs. Because the source code is included in the compilation, the functions will automatically adapt to the memory model currently in use. Also note that every function is defined before being referenced by other functions, thus eliminating any need for a header file containing prototypes (if you program using ANSI C conventions).

The down side of using source-level *#include* files such as VIDEO.I is that they waste memory. Turbo C doesn't optimize itself by pulling out unreferenced code. As a result, all the code for all the functions appears in every .EXE program that *#includes* VIDEO.I, even if the program calls only a single function. My solution to this is to make the functions into a linkable library (.LIB file).

Creating the Libraries

Building and linking with user-created libraries in Turbo C can be a bit of a chore. In the small model, the inclusion of VIDEO.I adds 1,376 bytes to the .EXE file; in the large model, 1,520 bytes. The overhead consists of total bytes minus the sizes of the functions you actually call. If that amount of code space is important to you, it might be worth turning VIDEO.I into one or more libraries so that only those routines that are actually used get linked into the .EXE file.

The first step is to write a file VIDEO.H that defines all the graphics function prototypes. Listing Two, page 84, shows this header file, which you should *#include* in any programs that link with the video library. You'll also use VIDEO.H in creating the library's individual members. Each function file should *#include* VIDEO.H at the top. Purists might also want to add comments explaining what the function does and to what library it belongs.

When all the functions have been broken out into separate files, compile them one by one with Turbo C to create a matching set of .OBJ files. Now you're ready to make the library.

The .OBJ files produced by Turbo C are in Microsoft-compatible format, so you can use the DOS LIB utility to combine them into a linkable library. To produce a library called VIDEOS.LIB containing the functions video *mode( )* and *activepage( )*, for example, type:

```
LIB VIDEOS + VIDEOMODE + ACTIVE-
                          PAGE;
```

Later you can add *setmode( )* and *setcursor( )* with the similar:

```
LIBVIDEOS + SETMODE +
                    SETCURSOR;
```

You can, of course, add more than two modules at a time to the library simply by specifying the library name first, followed by an entire command line of module names separated by plus signs.

The *S* on the end of the library name is a convention borrowed from Turbo C to indicate the memory model; here, it is assumed that you compiled the separate units in the small model.

To link with this library, first make sure it's in the directory where Turbo C looks for source files (not in the \TURBOC\LIB directory with the vendor's libraries). Put the entry VIDEOS.LIB in your project file (.PRJ). Turbo C then knows that you want to link to a user-created library and where to find it.

Repeat the compilation and LIB procedures for each memory model you use, varying the library file name accordingly (VIDEOT.LIB, VIDEOC.LIB, and so on). You'll have to modify the library name in your .PRJ file if you decide to change memory models during the development of a program.

Because it takes an hour or two to get through this whole business of making libraries, weigh the price in time investment vs. saving a thousand bytes or so in the .EXE file. It's your choice.

Adapting to the Adaptor

The box accompanying this article

GRAPHICS TOOLBOX

(continued from page 31)

(page 34) describes how to determine which video adaptor is present in the machine. Refer to it for the "theory"; this article concentrates on the practical aspects of applying the adaptor identification to APA graphics, specifically on the CGA and EGA. The principles discussed here are applicable to other adaptors, such as the Hercules, as well.

In text modes there's little adapting to do for a specific display type. The screen is always 25 rows high and either 40 or 80 columns wide. The 40-column mode only applies when writing text on a 320×200-pixel graphics screen; otherwise you're always in 80-column mode. The monochrome display adaptor (MDA) can't produce colors, but it can do normal, intense, underlined, and blinking (attributes remarkably similar to colors). Thus, although the demo program later in this article does a few text tricks using the video library, I'm not going to discuss them here. Because text graphics has its own set of problems and solutions, I'll save that discussion for Part 2.

When your software knows the video adaptor it's working with, it can alter its behavior to suit. After identifying the video board, the software can then adjust its coordinate system or color selections to fit the APA display. Here, in the interest of limited space, I'll show you how to make a program dynamically modify its coordinate system.

Suppose, for example, you want to draw a border around the screen, starting 15 scan lines (y points) below the top and ending 15 above the bottom. The width in either case is 640 pixels and the top of the rectangle is at y=15. However, the CGA has a mere 200 vertical scan lines, whereas the EGA has 350. Therefore, you can set up an assignment condition such as:

```
if (adaptor = = cga)
   bottom = 199–15;
else
   bottom = 349–15;
```

The trick here is to locate the bottom of the box, which is determined by the adaptor type. The vertical line-drawing routine can then repeatedly call the *plot()* function from the video library, with the number of calls—pixels plotted—being determined at run time by the type of adaptor available. Similarly, the horizontal line-drawing routine can draw the bottom at the appropriate elevation (y=184 or y=334, for CGA and EGA, respectively).

This is a somewhat simplistic scenario implemented in the demo program; a more complex application might consider CGA the default and supply a multiplier of 1.0 in calculating y coordinates. If an EGA is present, however, the program can substitute 1.75 for the y multiplier (because 350/200=1.75). Furthermore, if four-color graphics are required, it can use 1.0 as the multiplier for the default (mode *04h*=CGA 320×200 four color) and substitute 2.0 if an EGA is present (mode *10h*=EGA 640×350 four color). Thus the program dynamically redefines its coordinate workspace in both dimensions based on the available video adaptor.

A program that does extensive APA graphics will rely on the video library's *plot()* function, which plots

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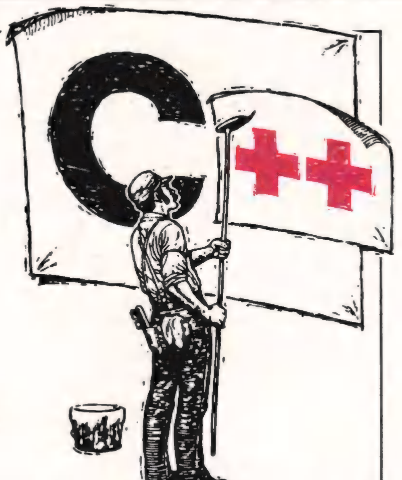

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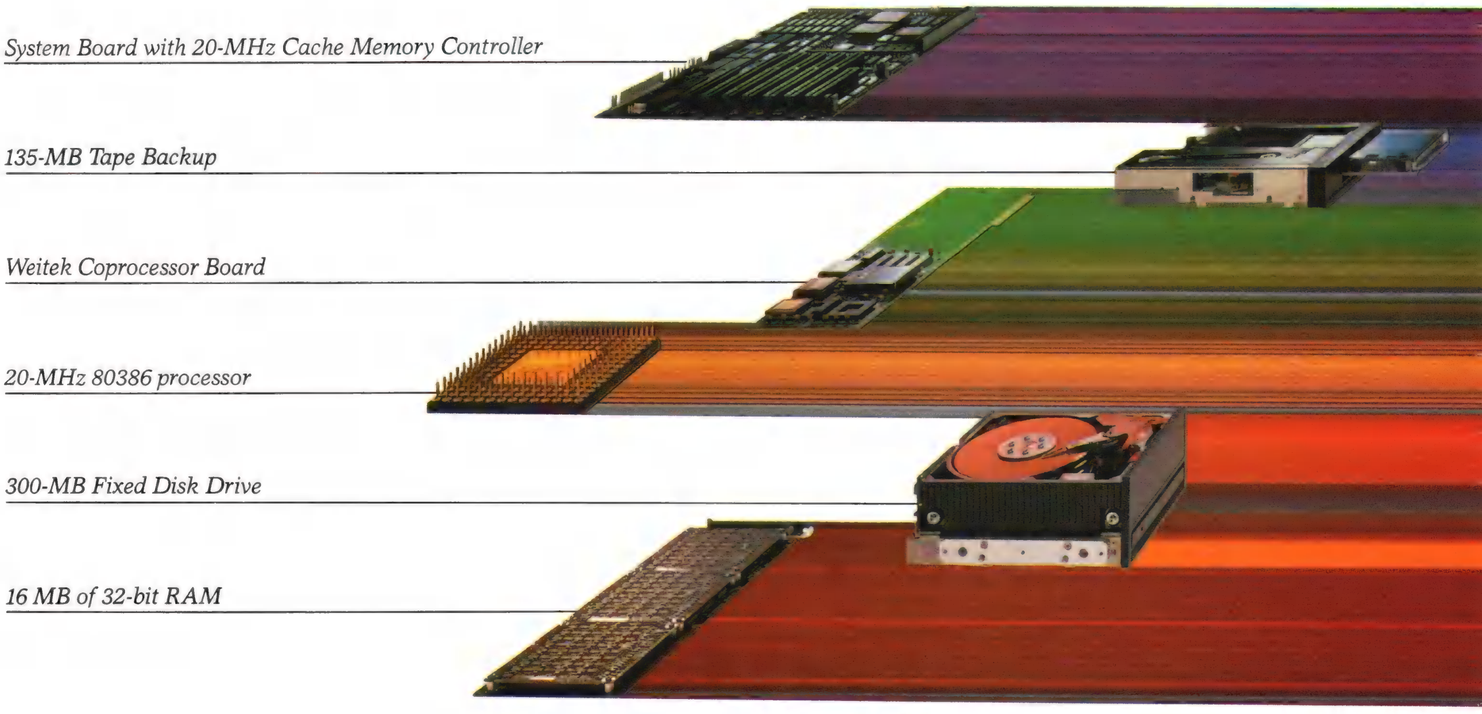

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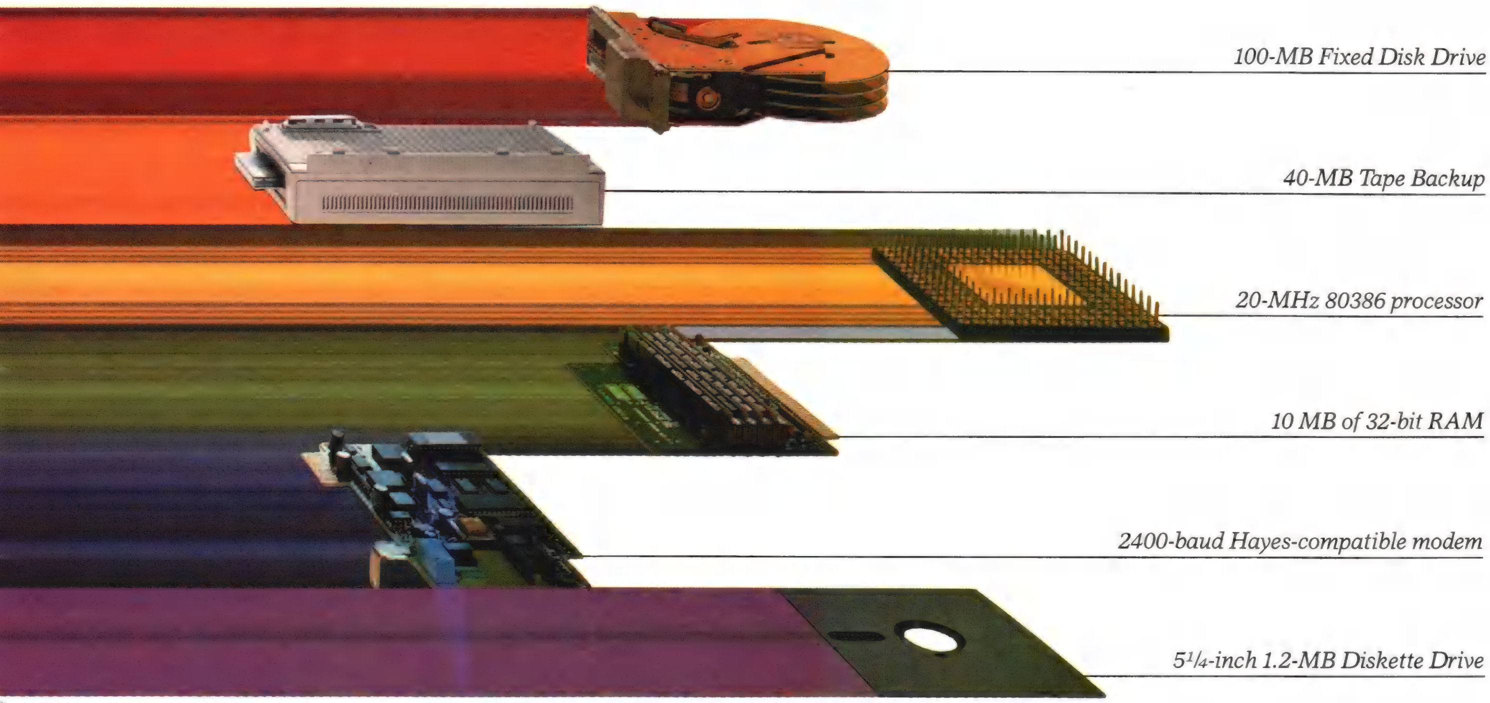

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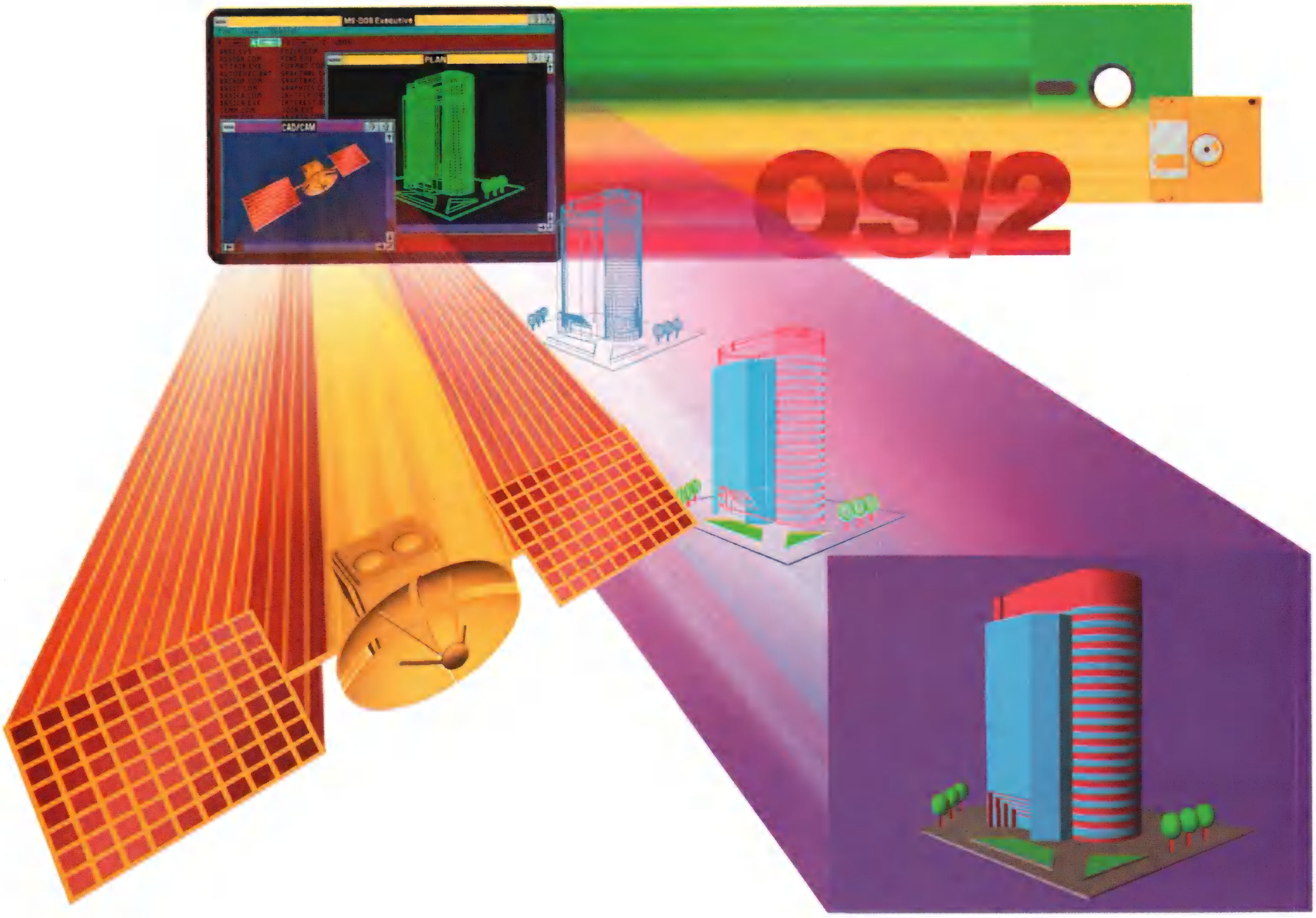

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GRAPHICS TOOLBOX

(continued from page 32)

individual pixels, but it could clearly benefit by some higher-level drawing routines.

Adding APA Graphics

Ultimately, all objects appearing on the display are composed of three kinds of lines: vertical, horizontal, and diagonal. Even a solid such as a block cursor or a complex filled polygon consists of some number of contiguous lines arranged so as to approximate a form that the eye recognizes. This suggests enhancing the video library with line-drawing routines that you can employ to create shapes.

For efficiency I developed orthogonal line routines and a separate, less efficient routine for diagonals.

There's less overhead in drawing orthogonal lines (vertical or horizontal) than in drawing diagonals. Why? Because diagonals proceed along a slope, or ratio between vertical and horizontal motion. Slopes are, almost without exception, fractional numbers that entail floating-point operations, which are inherently slower in computers. Slope is not an issue when drawing a line that is perfectly vertical or horizontal, and thus it can be done with more efficient integer arithmetic.

For efficiency, I developed orthogonal line routines and a separate, less efficient routine for diagonals. The latter is called if I know or suspect that the line is not orthogonal.

In the orthogonal routines, you pass the start and end points, the axis coordinate along which the line is to proceed, and the color of the pixel you want plotted. The routine then uses integer arithmetic to control a loop that plots the individual points. Listing Three, page 84, supplies two such routines, called *hdraw( )* and *vdraw( )*, for horizontal and vertical lines, respectively.

Because callers will probably use these routines frequently, passing variables as arguments, you should not place on them the burden of ordering the start and end points to suit the expectations of the routines. Consequently these routines sort the start and end into the low-to-high order they expect. The calls *hdraw (35, 231, 20, 1);* and *hdraw (231, 35, 20, 1);* both produce exactly the same result: namely, a horizontal line between x coordinates 35 and 231 inclusive along y coordinate 20 in color index 1.

In considering the diagonal routine *draw( )*, it's important to recognize several factors:

- The requested line might be orthogonal, resulting in a slope that is either 0 (horizontal) or infinity (vertical). To avoid division-by-zero failures, the routine must anticipate these problems in advance and take corrective action by preassigning the correct stepping value.
- The diagonal must move along the axis that results in the densest line, or in other words, along the axis that has the greatest distance to travel. If the motion is greater along the x axis than along the y, the more dense line results from plotting each y intersection per x increment. Thus the routine must determine the axis with the greatest movement and make that the controlling axis.
- The stepping value along the shorter-motion axis is a floating-point number that is the ratio of short-motion to long-motion. For example, if the x axis moves +120 points and the y axis –30, the x axis is controlling and the y moves –0.25 points per x (–30/120 = –0.25), which is its slope relative to the controlling axis.
- The stepping value is additive. That is, for each controlling increment, the stepping value is added to the current controlled value. This motion accumulates and is truncated or rounded for each controlling step, according to the way the routine is written (Listing Three truncates it).

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Identifying the Video Adaptors of IBM PCs

ROM BIOS interrupt *10h* on IBM PCs and compatibles furnishes video services to accommodate a variety of hardware configurations. Although many of the calls—notably those dealing with text—are device independent, others are device specific. If your graphics software is to function effectively in this kind of variable environment, it must adapt its behavior to suit the hardware. And to do that, it must first find out what the video hardware is.

This isn't as easy as it might sound. Programs that want to determine the video capabilities at their disposal usually have to look in several places, piecing together many clues.

Value	Adaptor
0	undefined[1]
1	40 by 25 B&W text, color graphics[2]
2	80 by 25 text, CGA[3]
3	80 by 25 text, monochrome

1. used by Compaq, EGA, and CGA
2. also used for non-IBM video devices such as Hercules
3. unreliable

Table 1 *BIOS video equipment flag*

Mode	Meaning
00h	40 by 25 B&W text, color graphics (obsolete)
01h	40 by 25 color text
02h	80 by 25 B&W text
03h	80 by 25 color text
04h	320 × 200 4-color graphics
05h	320 × 200 4-color graphics (color burst off)
06h	640 × 200 2-color graphics
07h	monochrome adaptor or EGA text mode
08h	160 × 200 16-color graphics (PCjr)
09h	320 × 200 16-color graphics (PCjr)
0Ah	640 × 200 4-color graphics (PCjr)
0Bh	not used
0Ch	not used
0Dh	320 × 200 16-color graphics (EGA)
0Eh	640 × 200 16-color graphics (EGA)
0Fh	640 × 350 2-color graphics (EGA)
10h	640 × 350 4-color or 16-color graphics (EGA) (depends on available display memory)

Table 2 *IBM PC line video modes*

The Video Equipment Flag

First I'll discuss sources of information about the video environment, then I'll show how to use them to identify the video hardware. At memory address *40h:07h*, the ROM BIOS keeps a byte called the equipment flag, which describes the machine's hardware configuration. Bits 4 and 5 give some information about the attached video device. By masking out the other bits and shifting right four places, you can isolate a device number from 0 to 3. In C, for example, you might write this operation as:

```
adaptor = (peek (0x40, 0x07) & 0x18)
                               >> 4;
```

A similar effect can be obtained in BASIC with the statements:

```
DEF SEG &H40
ADAPTOR = (PEEK (7) \\ 8) AND
                          &H03
```

Table 1, left, shows the full range of resulting values. As this table indicates, the BIOS video equipment flag byte raises more questions than it answers. The only thing that's sure is that when its value is 3, you have a monochrome (that is, text-only) adaptor. Even so, you might want to check further; if the video mode discussed next is 7, it's definite that the video device is incapable of APA graphics and color text.

The Video Mode

The ROM BIOS furnishes two methods for obtaining the video mode—that is, the current mode of operation for the adaptor. One is to call interrupt *10h* with function code *0Fh* in the *AX* register. On return, *AL* contains the mode value. An alternative is to bypass the ROM BIOS and do yourself what function *0Fh* does indirectly: read the video mode byte from location *40h:49h*.

Whichever, the resulting is a byte whose possible settings are shown in Table 2, left. These values can also be used to set the video mode, assuming the attached device is capable of supporting them. These values suggest the capabilities of the monitor by inference only and can be misleading. For example, although mode *07h* indicates an active monochrome display adaptor (MDA), it is also valid for the EGA in plain text mode.

Note that modes *0Bh* and *0Ch* are undefined; presumably these are reserved for future developments or for graphics adaptors that were never introduced.

The Enhanced Graphics Adaptor

If the current mode is anything less than *08h*, you have to investigate further to find out if an EGA card is present in the system. The ROM BIOS furnishes no call for this, so you have to read memory location *40h:87h* to find out. This address contains the EGA information byte.

Although each bit or bit pair in the EGA information byte has some unique significance, in general it's sufficient to know that the byte is 0 when an EGA is not present and nonzero when one is. Therefore, in C, you can define a Boolean function *isEGA( )* as follows:

```
char isEGA (void)
{
  return (peekb (0x40, 0x87));
}
```

which returns *FALSE* when there is no EGA attached and *TRUE* (some nonzero) when one is. Similarly, you can test for an EGA monitor in BASIC with statements such as:

```
DEF SEG &H40
IF PEEK (&H87) <> 0 THEN (EGA
              present) ELSE (not)
```

A brief discussion of the EGA is perhaps a worthwhile digression here. The EGA furnishes several extended all-points addressable (APA) graphics capabilities. That is, you can have more pixels of higher density with more colors than in the earlier graphics adaptors. How the EGA works is beyond the scope of this article. What's important is that the EGA is downward compatible; that is, it supports all the modes available in the earlier MDA and CGA, plus some of its own. The EGA offers no text capabilities beyond the CGA, except that the characters are more dense and thus more readable; this is a given, beyond programmer control. Otherwise the same combinations of 16 foreground by 16 background colors are available.

The advantages of the EGA over other adaptors thus involve only APA graphics. In text modes, the only discriminator is whether the display is pure monochrome (MDA) or not. If it's pure MDA, you can't do colors; otherwise you can.

Other Common Adaptors

The popular Hercules card offers APA graphics enhancements but nothing extraordinary by way of text. The Hercules provides for gray shading of text as a substitute for text colors and APA graphics on a 720 × 348-pixel monochrome display.

The Compaq adaptor is second only to the EGA in versatility. In text mode, it acts like the EGA's text mode, producing high-resolution text in any combination of 16 foreground and 16 background colors. You can also switch it into any of the CGA graphics modes (*04h–06h*) and it behaves just like the CGA adaptor.

Identifying a "Herc" or a Compaq, like the others, is a matter of recognizing a pattern of indicators.

The Software Sherlock Holmes

Now let's see how these clues fit together. Table 3, below, shows the "signatures" of several popular video adaptors in their default (power-up) conditions. Notice that each adaptor has a unique pattern of values. Given this, you can quickly sift through three items of information and identify the adaptor. Expressed in pseudocode, the algorithm is:

```
if EGA byte <> 0 then
  adaptor = EGA;
else
  case BIOS equipment flag of
    0: if video mode = 2 then
         adaptor = Compaq;
       else
         adaptor = CGA;
       end if;
       break;
    1: adaptor = Hercules; (see note)
       break;
    3: adaptor = MDA;
  end case;
end if;
```

Note: Some other monitors use the same signature as the Hercules does. An example is the MDS Genius full-page display popular with desktop publishing systems. In this case, you have to look at the display buffer size, which you can fetch as an integer from *40h:4Ch*. The Hercules display buffer is 16,384 bytes; that for the Genius is 8,192 bytes.

Obviously, then, Table 3 and the algorithm are not comprehensive. The great majority of video adaptors for IBM PCs and compatibles emulates one of these de facto standards, however, and thus the method presented here is reliable in almost all cases.

	EGA	CGA	MDA	Compaq	Hercules
BIOS equip.	0	0	3	0	1
Video mode	3	3	7	2	7
EGA byte	nonzero	0	0	0	0

Table 3 *Signatures of popular video adaptors*

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GRAPHICS TOOLBOX
(continued from page 33)

These considerations enable the routine to plot a diagonal or orthogonal line in any direction. The cost of this flexibility is slower performance.

As you use the video library, you'll undoubtedly add your own graphics routines for such things as polylines, filled shapes, circles, arcs, and so on. The DRAW.I file given here is merely a suggestion of the kinds of things you can do to make graphics easier in Turbo C.

You can also make life a little easier, and your source code more readable, by including the file COLORS.H (see Listing Four, page 85) in programs that require colors. It's always easier to understand identifiers than "magic numbers" requiring you to memorize, for example, that *07h* is light gray.

A Graphics Sampler

Now let's put this discussion to work in a demonstration program. Listing Five, page 85, contains the demonstration program VID.C, which calls a number of the routines in the video library. It produces some simple but illustrative effects in both text and graphics modes.

The program first identifies the adaptor on the host machine so that it can subsequently tailor its behavior to suit (or bypass operations that the adaptor can't handle, such as APA graphics on an MDA). This program is written to run on the MDA, CGA, EGA, and Compaq; it doesn't recognize the Hercules card.

Next it produces a text graphics display that showcases cursor positioning with *gotoxy( )* and (if the monitor is capable of color) colored text. Except for the string-writing functions that produce a label at the top and a prompt at the bottom of each demonstration display, this is the only use of text graphics in the program.

In the third display, the program draws a border around the screen and a large corner-to-corner X inside it. It calls the functions in DRAW.I. This routine shows how to make a run-time adjustment to the coordinate system according to whether the adaptor is a CGA (or Compaq) or an EGA. If you're running with an MDA, the program bypasses this display and the next because the hardware can't handle it.

The fourth panel is in CGA 320 × 200-pixel four-color graphics. It draws a three-color hourglass illustrating two things: first, that solids on a display are indeed composed of numerous horizontal lines; and second, that the EGA (if that's what you're using) can emulate a CGA monitor.

The final display merely announces that the demo is finished.

If you haven't converted the video functions into a linkable library but instead are using Listing One directly, change the indicated directive to *#include <video.i>* near the top of the file before compiling. On the other hand, if you've gone to the trouble of creating VIDEO.LIB, set up a project file VID.PRJ containing the following entries:

```
vid
video.lib
```

Make sure VIDEO.LIB is in the same directory as your source program VID.C, then start the compile, link, and go session with Alt-R.

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415) 366-3600, ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro).

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(Listings begin on page 82.)

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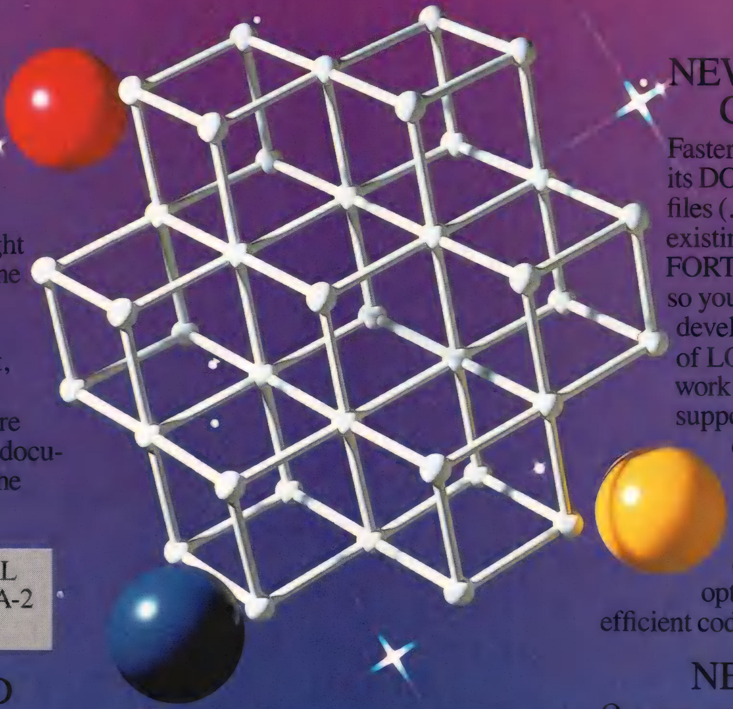

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CIRCLE 257 ON READER SERVICE CARD

A Graphics Toolkit for Turbo Pascal

by Hubert D. Callihan

Saving and restoring graphics screen regions

Although I've been using Turbo Pascal for custom graphics work for some time, I haven't come across much information on how to uncover the sometimes subtle graphics capability in Version 3.0. This article shows how I used several nonstandard Turbo Pascal procedures, including *GETPIC, PUTPIC, GETMEM, FREEMEM, BLOCKWRITE*, and *BLOCKREAD*, to create a set of tools for handling rectangular regions. You can use these tools, for which I have included all the source code, to develop:

- graphics pop-up overlay screens in either medium-resolution (320 × 200 pixels) or high-resolution (640 × 200 pixels) graphics modes
- multiple concurrent graphics regions that require rapid display
- rapid block-move animation

This set of tools consists of three procedures—*SaveRegion*, *RestoreRegion*, and *FreeBuffer*—along with one function—*CRTmode*—which collectively let you store to buffer and restore complete graphics screen regions or any upright rectangular subregions of the screen. I have also included two supporting procedures—*SaveBlockToDisk* and *GetBlockFromDisk*—which are useful for moving buffered screen regions to and from disk efficiently. (You need a CGA to make use of these routines.)

Dr. Callihan is chair of the Computer Science Department at the University of Pittsburgh at Johnstown where he has taught for the past 19 years. For the last 7 years, he has been actively involved in developing graphics tools.

Despite what you might think about the limitations of Turbo Pascal, the number of graphics regions that you can save to buffer simultaneously is limited only by heap space (that is, the dynamically accessible memory not already consumed by DOS, resident programs, the Turbo Pascal environment, the static program code, and static data). By operating in dynamic memory space, these tools exploit all the memory available on the PC that is managed by DOS. Turbo Pascal programmers who think they must stay within the 64K static limit will appreciate this feature; frankly, most of the criticism that has been leveled at Turbo Pascal regarding the 64K static limit is unfounded because, for a little inconvenience in notation and the need to allocate and deallocate memory, you can always get around the static limitation by using pointers.

I have successfully used these tools to develop menu overlays, images of fractals, Mandelbrot and Julia sets, splines, and custom animation code. Animation using repeated overlays of several images is a particularly good application for the tools because it depends in no way upon the complexity of the image but strictly on the amount of time required to restore the region to the screen once it is buffered. Even as complex an image as a Mandelbrot set, which may take hours to generate, can be buffered and restored at animation speed if no logical changes need to occur in the image. Drawing the individual frames, buffering each in memory, and displaying them in rapid sequence will produce the flip-card motion effect common in some types of animation, and because you don't need to erase one image before drawing another, the result is nearly smooth and flicker-free.

Saving Screen Regions

Listing One, page 92, contains the Turbo Pascal code for *SaveRegion*, the procedure that saves a screen region into a buffer. You call *SaveRegion* with arguments defining the rectangular screen region to be buffered, expressing the coordinates in absolute screen values; that is, medium-resolution x range 0–319 and y range 0–199 or hi-res x range 0–639 and y range 0–199. In addition, you must declare a pointer referring to a screen buffer containing the saved screen as a variable parameter argument.

SaveRegion itself calls *GETMEM* to allocate sufficient memory to hold the screen buffer, and then it calls *GETPIC* to get the picture from the screen and copy it into this buffer. The details for the *SaveRegion* input and output header are:

```
TYPE buffermemory : ARRAY [1 . . 3]
                              OF INTEGER;
  bufferaddress : ^buffermemory;
PROCEDURE SaveRegion ( VAR buff :
                             bufferaddress;
     x1, y1, {upper left coords}
     x2, y2 {lower right coords}
        : INTEGER );
```

Notice that array of three integers—*buff^[1]*, *buff^[2]*, and *buff^[3]*. Although they are somewhat enigmatically described in the Turbo Pascal reference manual, these three integers describing the parameters of the buffered screen must contain the following values:

- *buff^[1]*—an integer code for the current screen mode, namely 2 for *GRAPHMODE* or *GRAPHCOLORMODE* or 1 for *HIRES* mode
- *buff^[2]*—the width in pixels of the buffered region according to the mode in *buff^[1]*
- *buff^[3]*—the height in pixels of the buffered region

GETPIC stores the remaining screen image data in successive bytes after *buff^[3]*.

The program needs to know how much space the buffer for this screen region will need so it can dynamically allocate the memory via *GETMEM* and inform *GETPIC* about it. The documentation for *GETPIC* in the Turbo Pascal reference manual requires that this size be computed for medium resolution as:

```
size := ((width+3) DIV 4) * height *
                                  2 + 6
```

and for high resolution as:

```
size := ((width+7) DIV 8) * height
                                  + 6
```

These expressions account for the three integers (6 bytes) and the total number of bits needed to represent all pixels, where each pixel is either 2 bits for medium resolution (four colors) or 1 bit for high resolution (two colors). In either case, pixel width and pixel height are computed as follows:

```
width := ABS ( x1–x2 ) + 1;
height := ABS ( y1–y2 ) + 1
```

Calls to *GETMEM* and *GETPIC* with these parameters will allocate contiguous memory dynamically at the location determined by the pointer *buff*:

```
GETMEM ( buff, size );
GETPIC ( buff^, x1, y1, x2, y2 );
```

I use *GETMEM* rather than the standard *NEW* allocation procedure in Pascal because the amount of memory varies at run time for different screen buffer sizes and must be computed. *NEW* allocates space at run time but only according to the static *TYPE* declared at compile time; *GETMEM* permits it to be computed on the fly.

GETPIC actually permits any standard *TYPE* variable to be used to declare the buffer. An integer would suffice in most cases, but I use an array of three integers so that the resolution, width, and height are conveniently accessible using *buff^[1]*, *buff^[2]*, and *buff^[3]*, respectively. You will need these later when you want to display a screen region using *RestoreRegion* and/or free the memory consumed by its buffer.

The number of graphics regions you can save to buffer simultaneously is limited only by heap space.

Note that in Listing One I use the *max* and *min* functions locally within *SaveRegion* to filter the passed coordinates and thereby guarantee that they lie within the specified range for the current resolution mode. Note also the function *CRTmode*, which returns the current resolution mode of the graphics display, thus determining how *size* is computed.

My original versions of *SaveRegion* and *RestoreRegion* didn't have a *CRTmode* function; it required a global variable to carry the currently active resolution. Such globals are a nuisance when designing self-contained tools that abide by loose coupling principles commonly used in well-structured systems. In this case, I found that I could virtually eliminate side effects by creating a function to determine the current video mode. You just load the *AX* register with $0F00 and exercise ROM BIOS interrupt *$10*, and you get back the CRT mode-of-operation parameters in the *AX* and *BX* registers (see AT&T's 6300 documentation). Namely, the low byte of the 16-bit *AX* register contains an integer code corresponding to the current mode of operation (see Listing Two, page 92, for these codes). Although not used here, the high byte of the *AX* register contains the number of character columns in the text display if text mode is active and should be ignored in any graphics mode. The high byte of the *BX* register contains the current display-memory page.

Testing the CRT mode is a simple matter of declaring the usual register variables within a *RECORD* structure, setting the conditions for the interrupt to occur, calling the Turbo Pascal *INTR* procedure, and interpreting the returned results, as follows:

```
FUNCTION CRTmode
  ( VAR char__columns,
    display__page : BYTE ) : BYTE;
TYPE
  regpack = RECORD
    ax,bx,cx,dx,bp,si,di,de,es,flags :IN-
                                 TEGER
END; {regpack}
VAR dosreg : regpack;
BEGIN
  WITH dosreg DO BEGIN
    ax := $0F00;
    INTR ( $10, dosreg );
    CRTmode := LO ( ax );
    char__columns := HI ( ax );
    display__page := HI ( bx )
  END {WITH}
END; {CRTmode}
```

Restoring Regions to the Screen

Listing Three, page 93, contains the complete code for the *RestoreRegion* procedure. The heading for the *RestoreRegion* procedure is:

```
PROCEDURE RestoreRegion ( VAR
  buff : bufferaddress; x, y : INTE-
          GER; freeup : BOOLEAN );
```

You call it with arguments describing the lower-left screen coordinates (x,y) where the buffered region is to be placed on the current screen, and it uses the Turbo Pascal-supplied procedure *PUTPIC* to place the image at the point (x,y). *RestoreRegion* also expects the buffer

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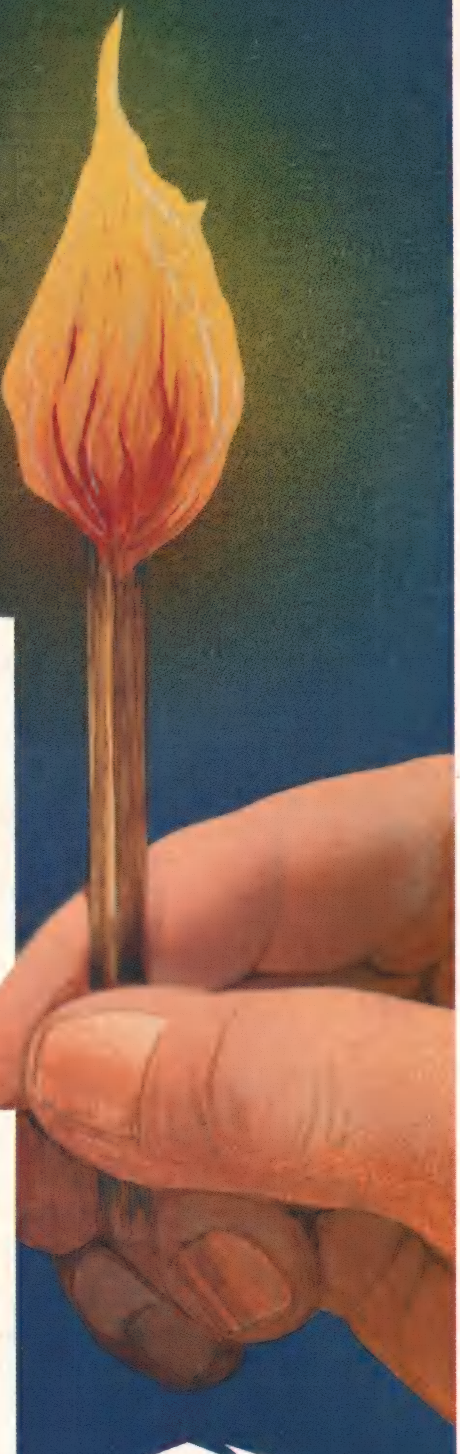

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TURBO PASCAL GRAPHICS
(continued from page 39)

pointer used by a previous *SaveRegion* call to be transferred in *buff*. Finally, there's that Boolean argument. I chose to use a *BOOLEAN* (called *freeup*) to indicate either that the restored buffer should be deallocated (*freeup = TRUE*) or that it should not be deallocated (*freeup = FALSE*), implying that the region may be restored to the screen again and again, as with a menu.

One caution: do not use the same buffer name on two successive calls to *SaveRegion* because this will render the first buffer inaccessible and you won't be able to deallocate it. If you must use the same buffer name in this manner, then copy the existing buffer into a *bufferaddress* variable name prior to the second call. Otherwise, a region corresponding to a given named buffer should be restored with the *freeup* argument set to *TRUE* before the same buffer is used again in a *SaveRegion* call.

RestoreRegion uses the resolution, width, and height parameters previously saved in the buffer to compute the amount of memory in *size* to be deallocated by *FREEMEM*. Note that it won't restore the image if any part of the region extends beyond the screen edges (*x_ok* and *y_ok*); two bells will sound in this case. Note, too, that the logic in this procedure permits you to remove this bounding-edge test, permitting partial image restoration.

Figure 1, page 44, illustrates a pop-up graphics menu that is used to overlay a complex fractal image. The fractal image is previously buffered using *SaveRegion*, and when restored using *RestoreRegion*, it overwrites the image containing the menu. The effect in such a case is to erase the menu and restore the background to its previous state.

Managing Memory

I found it wise to include in my bag of tools a procedure called *FreeBuffer* to allow me to deallocate an image buffer without restoring the image visually to the screen. Like *RestoreRegion*, *FreeBuffer* computes the size of the memory block to be freed and calls *FREEMEM* to com-

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Pattern matching replace	2:40 min	Cannot	Cannot	11 sec

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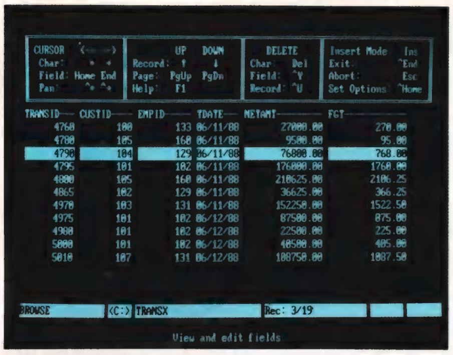

```
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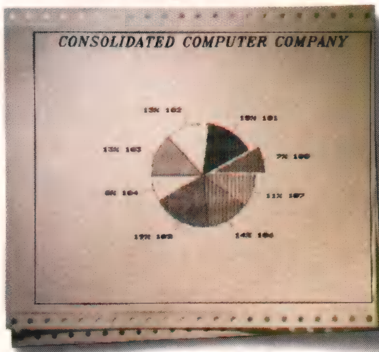

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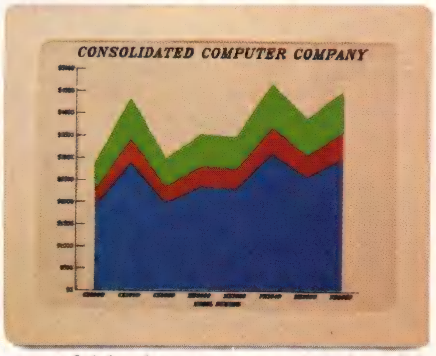

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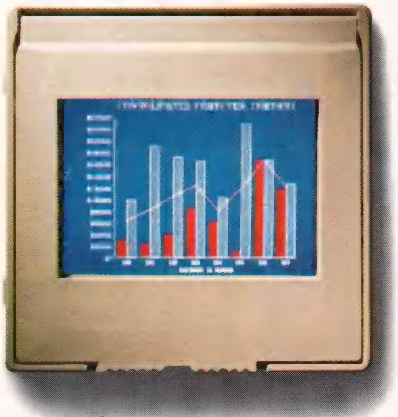
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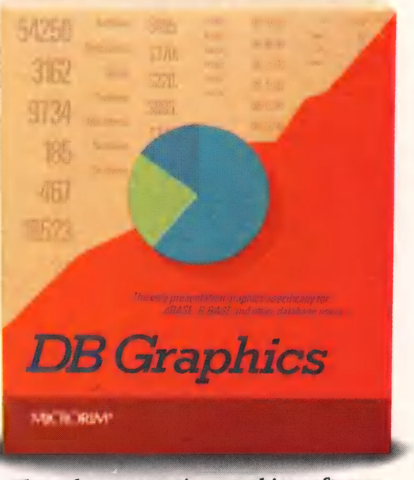

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CIRCLE 320 ON READER SERVICE CARD

(continued on page 40)

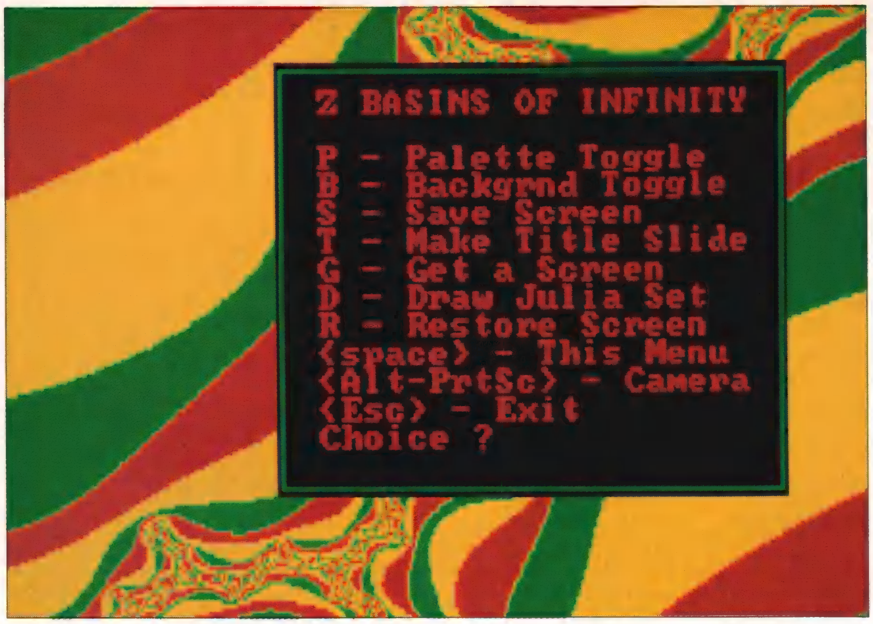

Figure 1: *The pop-up menu, previously drawn and saved, overlaying the fractal image*

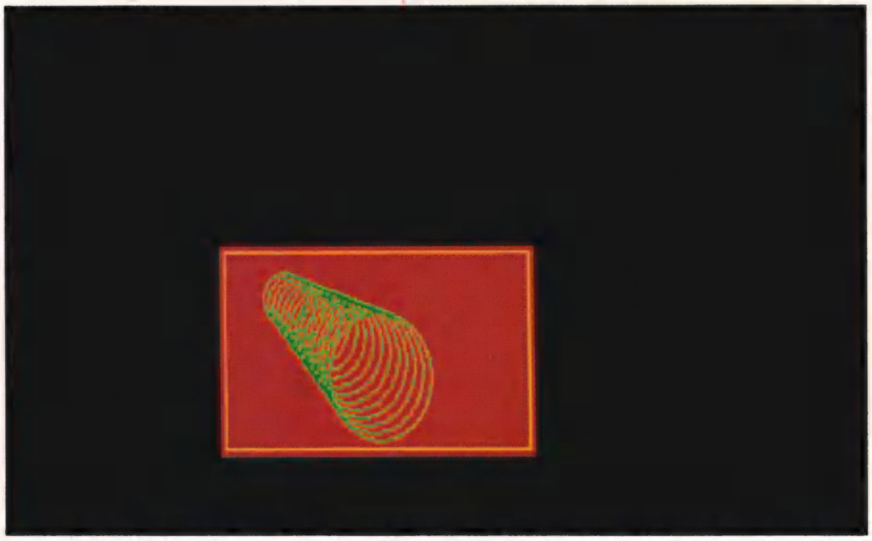

Figure 2: *A saved graphic region used in Listing Six as* buffer

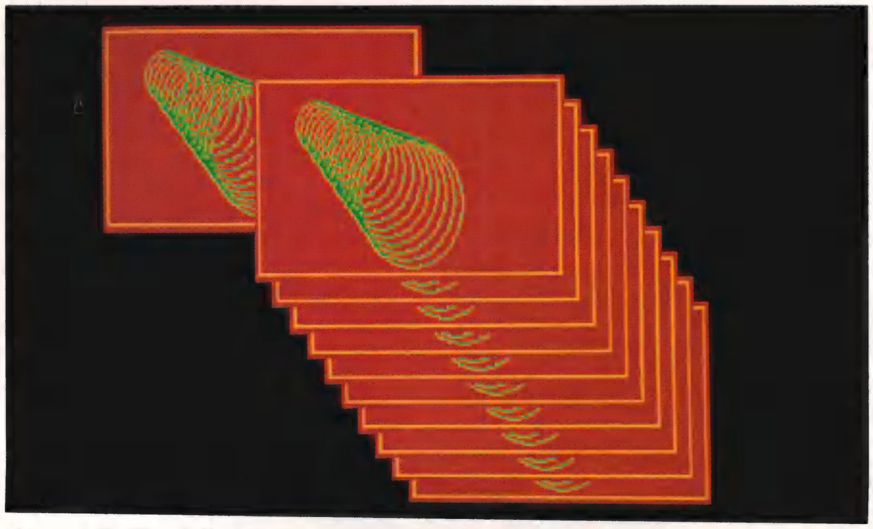

Figure 3: *The full screen saved as* buffer2 *in Listing Six*

plete the job. Listing Four, page 94, contains the complete *FreeBuffer* procedure. The procedure heading takes this form:

```
PROCEDURE FreeBuffer
  ( VAR buff : bufferaddress );
```

Storing Regions on Disk

Because an image is stored within a contiguous section of memory, it is possible to save it rapidly to an "untyped" disk file and later load it from disk into a buffer. Turbo Pascal provides for such untyped files, and its *BLOCKWRITE* and *BLOCKREAD*, as described on page 114 of the reference manual, will suffice for writing and reading the images.

You call *BLOCKWRITE* like this:

```
numrecs := 1 + (size–1) DIV 128;
BLOCKWRITE ( FileVariable, buff^,
                          numrecs )
```

because it saves a block of memory to a file named *FileVariable* consisting of *numrecs* 128-byte block records starting at *buff*. The last record may conceivably contain less than 128 bytes of true image data, wasting a few bytes, but the sacrifice of a few bytes of memory and disk space is well worth what you gain in speed by using block disk transfers.

To load an image back from disk into a buffer, you determine the size of the image file (in 128-byte records) using Turbo Pascal's *FILESIZE* function, allocate sufficient memory to hold the image using *GETMEM*, and finally, *BLOCKREAD* the records from the original "block written" file into the buffer:

```
SizeOfFile := FILESIZE ( FileVari-
                              able );
GETMEM ( buff, SizeOfFile * 128 );
BLOCKREAD ( FileVariable, buff^,
                       SizeOfFile );
```

Listing Five, page 94, contains the simple procedures *SaveBlockToDisk* and *GetBlockFromDisk* for saving and loading these buffered regions to and from disk.

Examples

Having hopefully whetted your appetite to see a demo, I submit the demo program in Listing Six, page 95. It creates the graphic region shown in Figure 2, page 44, saves it in a buffer (*buffer*), and restores it to various locations on the screen. A second buffer, *buffer2*, contains a full-screen image (see Figure 3, page 44) that serves as background for subsequent pop-up overlays. The program restores this image alternately with the smaller overlay, creating a motion effect.

Note that I have included GRAPH.P Extended Graphics (supplied with Turbo Pascal, Version 3.0) as an option if you want to use windows via *GRAPHWINDOW* and the window-clearing operation *FILLSCREEN*. If you use Turbo Pascal windows in this manner, then the coordinates in *SaveRegion* and *RestoreRegion* refer to the current window, where (0,0) is its upper-left corner.

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415) 366-3600, ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro).

Bibliography

System Programmer's Guide. AT&T 6300 Personal Computer Documentation, 1986.

Turbo Pascal V3.0 Reference Manual. Scotts Valley, Calif.: Borland International, 1987.

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(Listings begin on page 92.)

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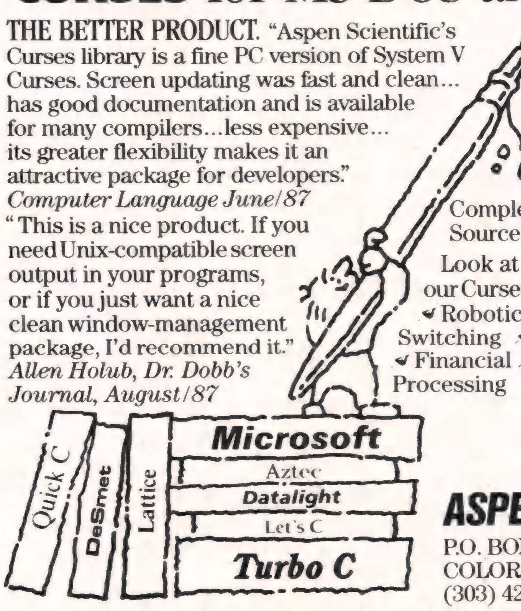

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CIRCLE 360 ON READER SERVICE CARD

Using EGA Graphics Screens in Your Programs

by J. Brooks Breeden

Getting a full-color screen from a paint program into EGA display memory from a high-level language

Creating detailed images for the Enhanced Graphics Adapter (EGA) usually means graph paper, binary-to-hexadecimal conversion, and counting lots of dots. Commercial "paint" programs such as EGAPaint and PC Paintbrush, on the other hand, offer real-time, see-what-you-draw image creation but typically only allow full screens of images to be chained in a sort of "slide show."

Once you display a screen (created by such a paint program) with your programming language, you can then use your language's graphics commands to modify the screen. You can capture bit blocks, animate portions of the screen, and save images to disk—all this and more, with no graph paper or binary-to-hexadecimal conversion and only a little pixel counting.

This article presents Forth routines that can be used to load an EGAPaint file into video memory for producing animation (see Listing One, page 88). Although Forth is the language used in the listing, the pseudocode in Listing Two, page 88, should enable you to adapt the method to any language supporting EGA graphics. The process is relatively straightforward. Listing Three, page 89, contains a demonstration of the routines' use in a simple game. But first, let's take a brief look at the Enhanced Graphics Adapter.

J. Brooks Breeden, 367 Brynhild Rd., Columbus, OH 43202. Brooks is a professor at Ohio State University. He worked with CAI on mainframes from 1976 until 1981, when he switched to using the IBM PC. He has worked with Forth exclusively since 1984.

An EGA Review

Since its introduction in 1984, the IBM Enhanced Graphics Adapter (EGA) has received much less press than did its older sibling, the Color Graphics Adapter (CGA), in its first three years. The CGA's introduction was followed by a plethora of $20 books on how to program graphics (mostly in BASIC), but despite the introduction of many low-price EGA clone boards, information on taking advantage of the EGA's capabilities is still scarce. The EGA is more complex than the CGA and programming the EGA does require some understanding of the fundamental differences between them.

In its high-resolution mode (640 × 200 pixels, black and white), the CGA uses 1 byte to store data for eight pixels, 1 bit per pixel, either on or off (see Figure 1, page 47). The CGA memory required for a single page of hi-res display is therefore 16,000 bytes (640 × 200/8 = 16,000), although 16K (16 × 1,024 = 16,384 bytes) is allocated. CGA memory begins at B800h for even scan lines; odd scan lines are offset by 8K (8,192 bytes). The extra 192 bytes are not used in either area.

In contrast, EGA hi-res graphics display memory begins at A000h (see Figure 2, page 47). Unlike the CGA, display memory is continuous, not separated into even-line and odd-line locations. In its high-resolution 16-color mode, the EGA uses 1 byte to represent 16-color data for eight pixels, 1 bit per pixel. No, you didn't read that wrong.

Forgetting color for the moment, the EGA display is a matrix of 224,000 dots (640 × 350 = 224,000). If the display is either black or white, each dot or pixel can be represented by 1 bit (either on or off), just like the CGA in its hi-res mode. One byte represents eight contiguous pixels on a scan line, so 28,000 bytes (224,000/8 = 28,000) contain pixel data for one full screen.

But what about color? Let's first examine how a color printer "paints" an image. Color printers usually make four passes per line. Simply stated, color printing involves mapping areas of a page that receive a color, then applying the ink to those areas of the page. Successive mapping and application of cyan, magenta, yellow, and black inks (pigments that reflect light) yield a full-color image.

The EGA similarly uses a "map mask" to determine which phosphors (that emit light) should be excited in red, green, blue, and intensity "planes." One screen full of pixels (28,000 bytes) maps all areas of the screen that contain red in the displayed color, a second 28,000-byte screen maps all areas containing blue, a third maps green, and a fourth maps the associated intensity. The pixels mapped from all four planes blend visually to make the full-range color display. The EGA display, then, can be visualized as four overlaid planes of color, numbered 0–3, each having the same address—A000h. Yes, the *same* address. If the CGA is a single family residence, the EGA is a four-unit apartment building.

In addition to display memory, the EGA card contains control registers and temporary latches. The control registers are accessed by writing data to a port. To write to the display, you first set the control registers and read the byte at the desired address and then write the new byte to the same address. Reading the byte (eight pixels at a time) causes the EGA to read 4 bytes, one from each plane, into the temporary latches (eight pixels' worth of data in four colors). When a data byte is then written back to the same address, the values in the control registers at that time determine how the data gets written to each of the four planes. Map masks determine which plane is written to, and bit masks determine which bits are on in the byte that is written to the plane. The bibliography lists references that cover this sort of low-level programming in detail.

High-level languages supporting the EGA typically hide the complexity of such bit-level operations in commands such as *LINE*, *ARC*, and so on, but most do not implement all of the EGA functions. To do some things, you still have to resort to low-level programming. Although map-mask/bit-mask programming may appear excessively tedious, it is easy to do some things with the EGA, and moving data from storage to the display is one of the easiest. Displaying a screen image on the EGA means simply moving data representing the blue, red, green, and intensity planes from the source to the display address (the same address, the video *segment:offset*). You set the control registers (by writing values to the ports) such that the latches send the data being read to the appropriate plane. (Sending the blue data to the red plane results in bizarre color schemes. Go ahead, try it!) The only problem is finding out where the data for each plane is stored in your paint program's file.

Paint Your Wagon

EGAPaint, a popular paint program from RIX Softworks is used in the listings. Like other paint programs, it allows screens of images created with a program to be printed or saved to disks as files (either compressed or uncompressed). A printer utility, EGAPrint, is included to allow capture of anything being displayed to an uncompressed file in EGAPaint format.

The standard 640 × 350-pixel, 16-color file format for EGAPaint 2001 is 112,016 bytes: 16 bytes of color palette information, followed by 28,000 bytes each of blue, red, green, and intensity, in that order. (I called RIX and asked!)

The newer EGAPaint 2005 file formats vary depending upon the type of screen—for example, 640 × 350, 640 × 480, and so on. RIX says it will share uncompressed file-format information with any registered owner of the program who writes and requests it (I'm still waiting), but it will not share the compression scheme it uses. *ARC* seems to work fine for long-term storage, though. Other paint programs may save color plane data in a different order and might include palette color data in a different location (or not at all). A letter or call to the program vendor is worthwhile if some experimentation doesn't discover the proper sequence quickly.

Moving Right Along

You can program the EGA using any language that lets you do the following things:

1. read and write to an absolute address
2. read or write to a specific I/O port
3. call an external subroutine or a DOS interrupt

For example, to set write mode 0 in Turbo Pascal you use *port[$03CE]:=5* to select the register, then *port[$03CF]:=0* to set the register value. In BASIC you use *out*:

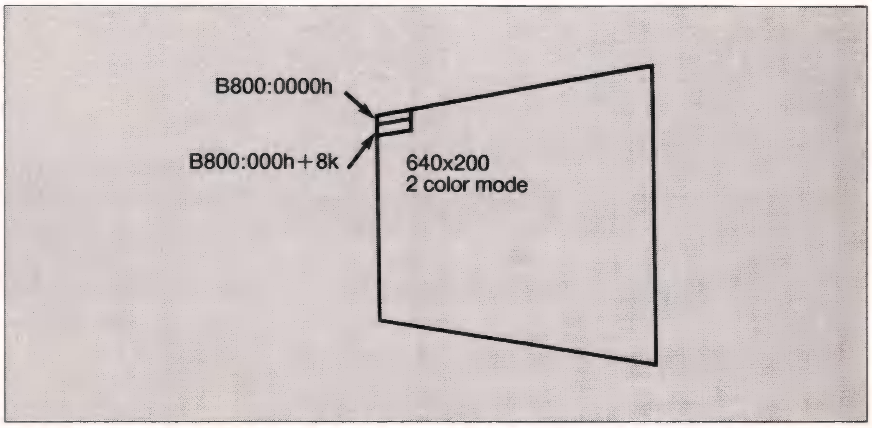

Figure 1: *Conceptual representation of CGA display memory. The plane is 16,000 bytes; 1 byte controls eight pixels.*

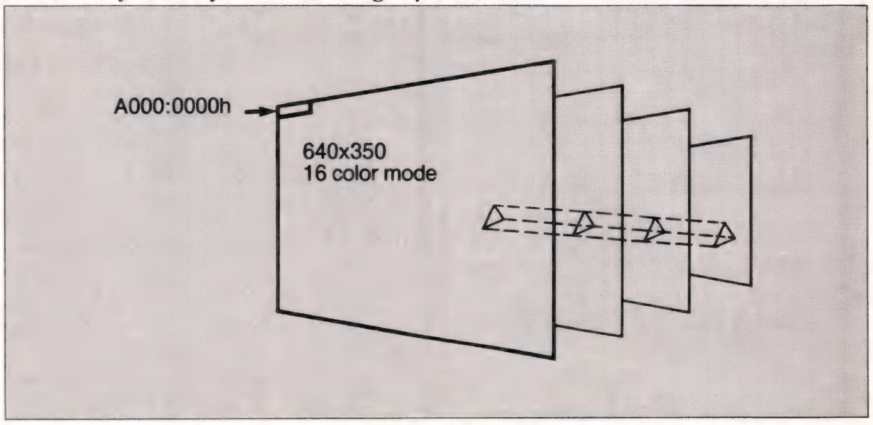

Figure 2: *Conceptual representation of EGA display memory. Each plane is 28,000 bytes; 1 byte controls eight pixels for all planes. You read and write to the same address. The latches deliver to the previously selected plane(s).*

(continued from page 47)

```
100 out &h3ce,5
110 out &h3cf,&h0
```

In UR/FORTH, the word *PC!* sends a byte to a port. The sequence becomes a word:

```
: WriteMode0 ( --- )
   HEX 5 3CE PC! 0 3CF PC! DECIMAL ;
```

Listing One contains the required routines written in UR/FORTH 1.01 (MS-DOS version), a Forth-83 implementation from Laboratory Microsystems; Listing Two contains a pseudocode version. The listings don't include saving a screen to disk because the paint program creates the image and does the save-to-disk. As they say in academe, reversing the process to save a screen to disk is left as an exercise . . . .

A Mindless Game of Motor Skill

Figure 3, page 49, is a dump from my sample program. EGAPaint was used to create a rear view of a Fokker Dr.1 triplane. After 8 × Zoom "detailing," the Fokker was saved as an EGAPaint file of 112,016 bytes. A UR/FORTH application then loaded the EGAPaint image using the routines shown in Listing One. Once the EGAPaint screen was displayed, UR/FORTH's bit-block save routine, *@BLOCK*, was used to save a rectangle of screen image surrounding the Fokker to memory. (That's where the pixel-counting comes in.) The block image was then written to disk by UR/FORTH as a DOS file of approximately 3K, and the 112,016 byte EGAPaint file was deleted.

This Fokker image was used as the principle image for a World War I shoot-'em-up dogfight. In the game, the Fokker image is loaded from disk to an allotted memory area and repeatedly written to the display using UR/FORTH's *!BLOCK*. Obviously, cursor keys control (move the Fokker relative to) the gunsight of your aircraft, and the Fokker pilot has a will (mind?) of his own as his range of random motion changes as hits are scored.

Animation of detailed images is a natural outgrowth of this technique because complicated rotations and so on can be captured as a series of frames that can be loaded into memory, rapidly swapped, then discarded. Currently, I'm using this method in developing computer-assisted instruction (CAI) modules for my courses. As virtual memory becomes commonplace with OS/2 et al., we may see this technique used increasingly. Until then, experiment, and if you discover something, for goodness sake, publish it!

The program begins with initial credits and a menu. When play begins, a Fokker Dr.1 triplane, a gunsight, your remaining ammunition, and the number of hits scored are displayed. The Fokker is moving slowly and is unaware of your presence. Your mission is to maneuver your plane (the gunsight) into position behind the Fokker and score 20 hits in the fuselage area. The space bar fires the guns.

Remember, you are flying the pursuit aircraft (the gunsight) not the Fokker, so the controls take a little getting used to. The number pad is your "stick." Pressing the up arrow

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key (8) pushes the stick forward, and because the gunsight is "fixed" in the center of the screen, diving makes the Fokker move (relatively) up! Similarly, pulling back on the stick with the down arrow key, pulls your plane's nose up, making the Fokker move down. Left and right arrow keys move you left (the Fokker moves right) and right (the Fokker moves left). Got it? The diagonal keys function, also. This is useful because you will often want to pull up and left, or push down and right, simultaneously.

When no cursor key is pressed, the Fokker simply flies off-screen upward to the left, which is analogous to your plane diving to the right. This is undoubtedly a function of the random-number generator's less-than-perfect randomness. What is ironic, though, is that it is exactly what would tend to happen were you to let go of the controls in a Sopwith Camel. "The Camel spun very quickly, had a very sensitive elevator control, and was very quick on right-hand turns due to the gyroscopic effects of the heavy rotary-engine and the short fuselage."

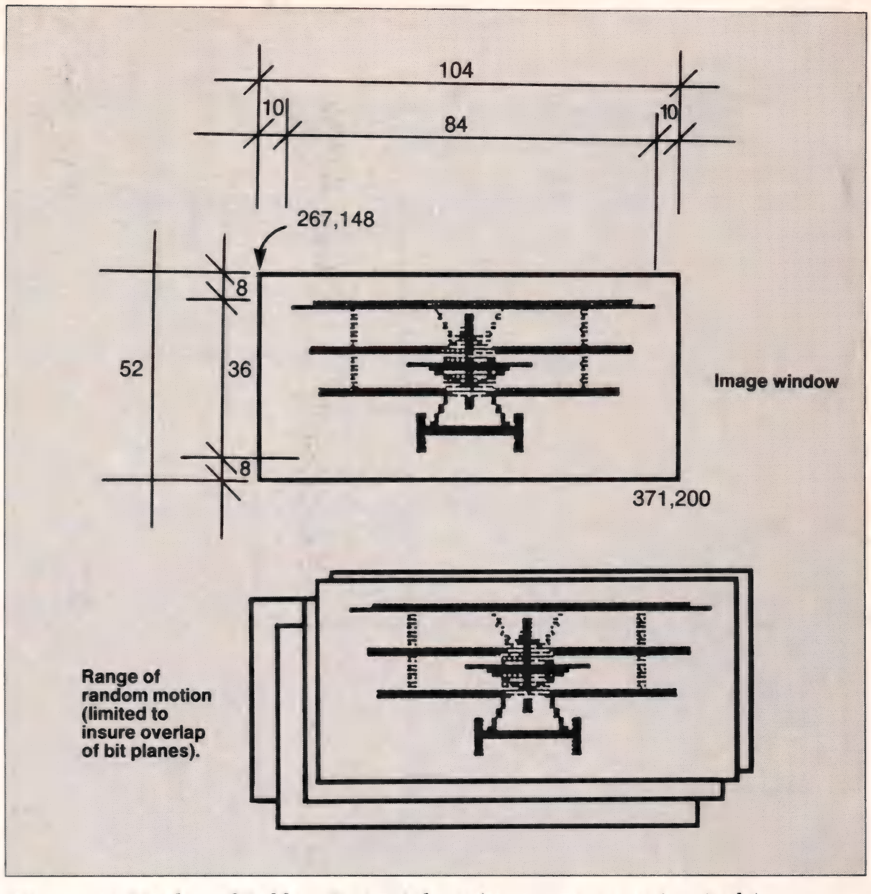
104
10
84
10
267,148
8
52
36
8
Image window
371,200
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Figure 3: *Display of Fokker Dr.1 triplane (measurements in pixels)*

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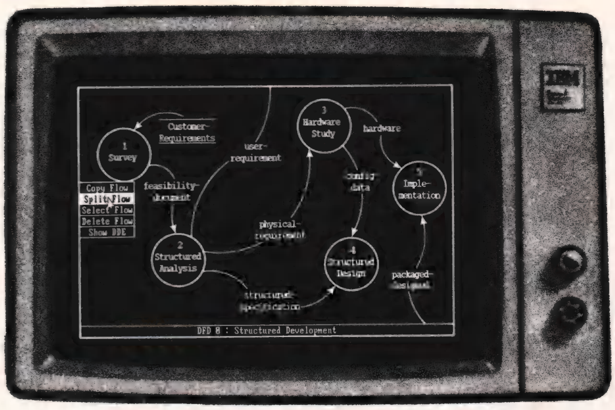

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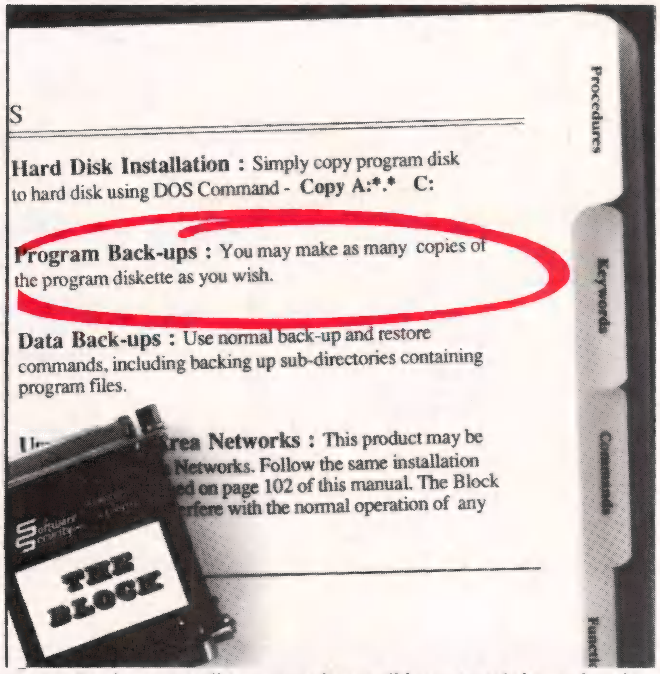
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EGA GRAPHICS
(continued from page 49)

(Campbell, 1984).

To just type and run the program without modification, you need UR/FORTH (a segmented Forth-83 model) from Laboratory Microsystems. The video driver, EGAGRAPH.EXE, must be installed before UR/FORTH. The file DERFOKKR.IMG, which contains the image created with EGAPaint, must also be in the active directory. Using the technique I have already described, you may wish to build your own aircraft with a paint program, load it into video RAM, and use the bit-block operator *@BLOCK* to capture the image to memory. You then only have to write the image to a file from which it can be loaded whenever needed.

The fundamentals of the game are neither specific to Forth nor to the EGA. Alternately, you can build an aircraft using simple lines and boxes that will work adequately with the CGA. Figure 3 shows the basis for the bit map and how that image is overwritten. Because the Fokker bit map is located by the coordinates of the upper-left corner, the fuselage "hit zone" is simply offset by a similar range of coordinates surrounding the corner.

The area of sky within the bit map beyond the actual image is used to blot parts of the previous image when a new one is written. The extent of the "extra" sky is thus directly related to the amount of random motion allowed with the image. Experimentation resulted in limiting the maximum range of random movement from the current location to plus or minus four pixels. Combined with a possible two additional pixels' movement from a cursor keypress, the maximum Fokker movement is six pixels per loop cycle. The area of sky surrounding the Fokker would allow for more random motion without leaving garbage all over the screen, but I don't think you'll really want it.

The program was developed using both a Compaq Deskpro (8086) and a 6-MHz IBM PC/AT, with the QUICKEYS.COM keyboard speedup program. QUICKEYS.COM was listed in a back issue of *PC Magazine* and can be downloaded from its IRS bulletin

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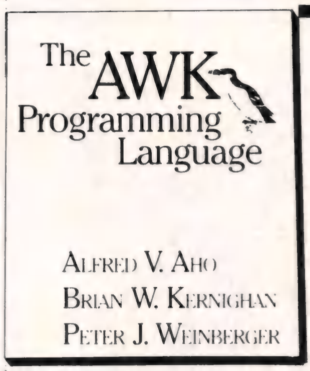
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CIRCLE 249 ON READER SERVICE CARD

(continued from page 51)

board. (Ray Duncan reports that Cruise Control also works.) FOKKER runs fine, albeit a little slowly, on a vanilla PC without QUICKEYS, but with anything faster than a 4.77-MHz 8088, it requires some sort of keyboard speedup program. The normal keyboard routines just don't read the stick routines fast enough, and the Fokker flies off the screen despite all efforts to catch him.

UR/FORTH users may want to use Tom Almy's Native Code Compiler to make the game faster on a standard PC, but it really doesn't need the extra speed on faster machines. On both Compaq 386 and Zenith 386 models, it is really too fast and probably ought to have a slow-down loop in the gun firing routines added. The rate of fire varies with the processor, also. An 80386 will fire at about 480 rounds per minute (per gun), a possible but high rate. (World War I aircraft synchronizers varied the rate of fire with engine speed.)

The Game Listing

The source is heavily commented. Probably the easiest way to understand the game is to examine the main loop definition on Screen 15. After setting initial values, display mode, and so on, *DOGFIGHT* enters a *BEGIN...AGAIN* loop. *DR.1* puts the Fokker bit-map address on the stack. Next, the current screen coordinates of the upper-left *CORNER* of the bit map are fetched to the stack. *MOVEFOKKER* leaves two random values within the current *RANGE* of random motion on the stack. These are vector-added to *CORNER*'s x and y. *?STICK* then determines if a cursor keypress is in the buffer and, if it is, leaves values appropriate to the key pressed on the stack; otherwise, it leaves a pair of 0s. The *?STICK* values are then vector-added to the previously "moved" corner values, and the Fokker is displayed at the new location by *!BLOCK*. What this does is randomly shift the Fokker's position and allow your keypress to counteract (somewhat) the random shift.

Next, *SHOOTING?* (defined in Screen 10) polls the keyboard and, if a key has been pressed, checks to see if it was the space bar. If it was, then if there is any *AMMO* left, it fires the guns, decrementing the ammo by two rounds, and calls *HIT?* (defined in Screen 9) to see if *CORNER* is within the x,y range that describes a hit in the Fokker's cockpit zone. If there is a hit, it's actually two hits (two guns, right?), and so *#HITS* is incremented by 2. With each four hits *EXCITEMENT* increments the *RANGE* of random motion and the Fokker pilot shouts a curse, in German, to distract you. To avoid offending anyone, I have made the curses in Screen 8 merely illustrative, but you can probably come up with somewhat more irritating and appropriate phrases.

Back in the *DOGFIGHT* loop, you now check *#HITS* again to see if the Fokker has been hit 20 times. If it has, it *EXPLODE*s with three *BURST*s, and you *WIN* and *EXIT*. If it hasn't been hit 20 times, you check the *AMMO* remaining. If it's zero, you *LOSE* and *EXIT*. Finally, you redisplay the *GUNSIGHT*.

The code for *?stick* in Screen 7 leaves –2s, 0s, or +2s depending on the key pressed. Initially, the *RANGE* of Fokker motion is set at –1 to +1. This means that you can outfly the

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Fokker easily, at first. With each four hits in the fuselage of the triplane, however, *RANGE* expands by –1 and +1: after the first 4 hits, *RANGE* is –2 to +2; after 16 hits, it is –4 to +4—twice the range of control you have with the numeric keypad. Because you are making a conscious effort to move in one direction, and the Fokker is moving randomly, you can still get him in your sights after 16 hits (statistically). But he doesn't stay there very long!

Screen 1 loads UR/FORTH's DOS level-2 interface and builds the file-handling words. Screen 2 assumes you have a file containing the Fokker image, called DERFOKKR.IMG, in the same directory and loads it into memory. Note that *DR.1* allots 3,000 bytes whereas the file is only 2,866 + 16 (palette) bytes long.

There is something funny going on in LMI's sizing of arrays for *@BLOCK* and *!BLOCK*, and the "correct" values seem to pick up garbage somehow; the "oversized" 3,000 bytes is empirically adequate.

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415) 366-3600, ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro).

For non-Forth programmers with an EGA display who want to pit their skill against the red Fokker, a complete unprotected run-time version (load-and-go .EXE file) is available from me for $14—cash, check, or M.O. only; no purchase orders, please. Have fun!

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(Listings begin on page 88.)

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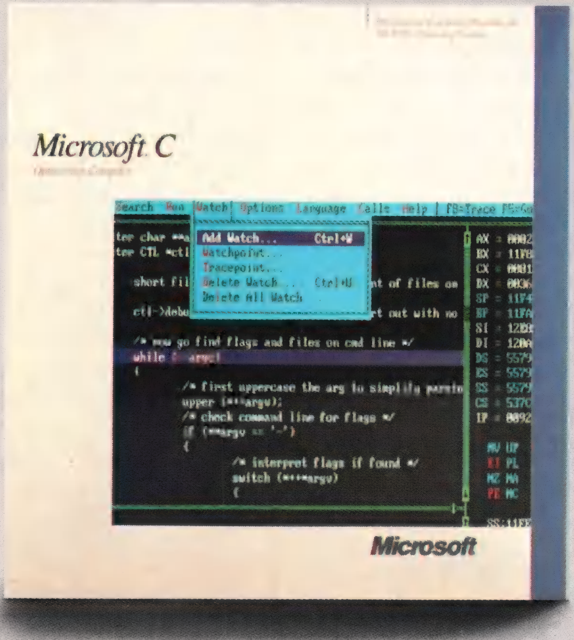

Automated Interrupt Handling in C

by Ron Miller

Make your own TSR utilities

A good case could be made that anything that makes the writing of resident programs easier is socially counterproductive. There are too many of those darned things already. But at times it can be useful to hack out a quick resident utility to serve a transient purpose such as reconfiguring hardware on the fly or offering an extra help screen, in much the same way as it is sometimes useful to hack out a file filter or a printer configuration utility. If you need to do such things, doing them in a high-level language adds immeasurably to the ease and accuracy of the results.

Any MS-DOS programmer who writes memory-resident utilities or works with serial communications knows that coding interrupt handlers is a task that quickly becomes tedious without ever becoming routine. Debugging one more run of assembly language—especially some assembly language triggered by another program—inevitably burdens any project with considerable overhead. If only there were some way to get the requisite *PUSH*s, *POP*s, *CLI*s, *STI*s, and *MOV*s straight once and for all.

If a set of assembly-language routines for interrupt handling could be regularized and debugged and compiled, the modules could be stored away in a library for linking with high-level code used for the bulk of the interrupt handlers themselves.

Unfortunately, interrupt handlers are exceedingly specialized objects. Different registers must be set and preserved; different interrupts called; and in some cases, flags must be returned intact. The programmer who writes everything from scratch in assembly language at least retains absolute control over all registers and flags, but once you move into a high-level language such as C, the registers and flags cease to be easy to supervise. If every line of C must be scrutinized to determine what registers will be altered and what flags will be set, why not just stick with low-level coding?

I have, I believe, devised something close to a minimal system for automating the process so that interrupt handling, no matter how complex, can be taken out of the realm of assembly language and be made routine. Inevitably, there are patches of assembly language in the system, and some of it is compiler and/or memory model dependent. These routines, however, can be done once, then put away for linking on demand.

A Sketch of the Process

The key to successfully implementing this system is a two-step procedure in which a standardized low-level handler is invoked by the interrupt itself. This invariant first stage transforms the registers (and the stack, if necessary) so that the routine can act as a simple C function that calls another C function to do the actual work of the handler. This reestablishment of the C environment allows the high-level handler to use the full range of C syntax, to access the run-time package, and to employ automatic and previously initialized static variables. Variations from handler to handler can thus be confined to the far more easily maintained context of a high-level language.

Four linkable assembly-language routines are involved in every application:

1. A trivial initializing routine that stores the data segment of the C code in the code segment of the low-level handler.
2. A generalized low-level handler routine that:
   - *PUSH*es the registers
   - resets the *ds* register (and perhaps other registers) to the values needed for operation by the actual resident C code
   - calls the high-level handler itself
   - *POP*s the registers on return from the high-level handler
   - returns from the interrupt itself
3. An interrupt function that can address the operating system from within the high-level handler. As you will see, this function must use the register stack generated by the low-level handler routine as its data-in and data-out structure.
4. A routine that swaps the 32-bit address of the low-level interrupt handler for the interrupt vector being captured while moving the original vector to an unoccupied location in the interrupt table for calling or chaining.

Ron Miller, 1157 Ellison Dr., Pensacola, FL 32503. Ron is a regular contributor to Micro Cornucopia.

In the code fragments to follow, I neglect to set up the necessary *PROC*s, *ASSUME*s, and *SEGMENT*s for linking because those housekeeping details will vary from compiler to compiler. The *[bp+xx]* addressing may be displaced by a word or two from what you need, but a glance at a bit of assembly-language output from your compiler should reveal the necessary adjustments.

Storing the Data Segment Address

At the very least, for a handler's resident C code to work properly, the *ds* register must be reset to its original value. This is made possible by inserting a *saveds()* call somewhere in the initializing code before any vector swapping is carried out.

Coding interrupt handlers is a task that quickly becomes tedious without ever becoming routine.

The object library of the programmer should therefore contain a compiled version of the following code:

```
  PUBLIC saveds__,c__ds
c__ds dw 0 ;In-code storage slot for
                                DS.
saveds__: ;Or however your compiler/
                   assembler alters
        ;public names for assembly
                -language reference.
  mov cs:c__ds,
  ret
```

This assumes that your handler is not so complex that it requires a separate stack; if it does, *ss* and *sp* for the internal stack could also be squirreled away for recall. My advice, however, is to keep auto variables to the minimum needed for communication between C functions. Play storage games with static variables if considerable storage is needed. Keep it simple; use the other fellow's stack.

The Low-Level Interrupt Handler

The outline given earlier provides the rationale for the code in Listing One, page 100. This routine, labeled *Lhand1()*, provides the segment/offset address actually inserted into the interrupt table. In all the code to follow, I use the prefix *L* to tag low-level interrupt handlers and *H* to tag high-level ones.

Because some interrupts return information in the flags, you cannot use *iret* to end the routine. *FAR ret 2* strips the old flag off the stack to preserve the return. If this routine is not assembled as a *FAR* procedure, the *ret 2* must be replaced by *db 0cah,2,0* so that a *FAR* return to the caller is made. I urge you, if at all possible, to write your high-level handlers in a "large" C so that all calls and returns are *FAR* and so that the entire memory of the computer is available to operations using pointers. The small decrease in code size using a small-model C is more than paid for by the need to allocate peek and poke room in the data segment when *FAR* manipulations must be made.

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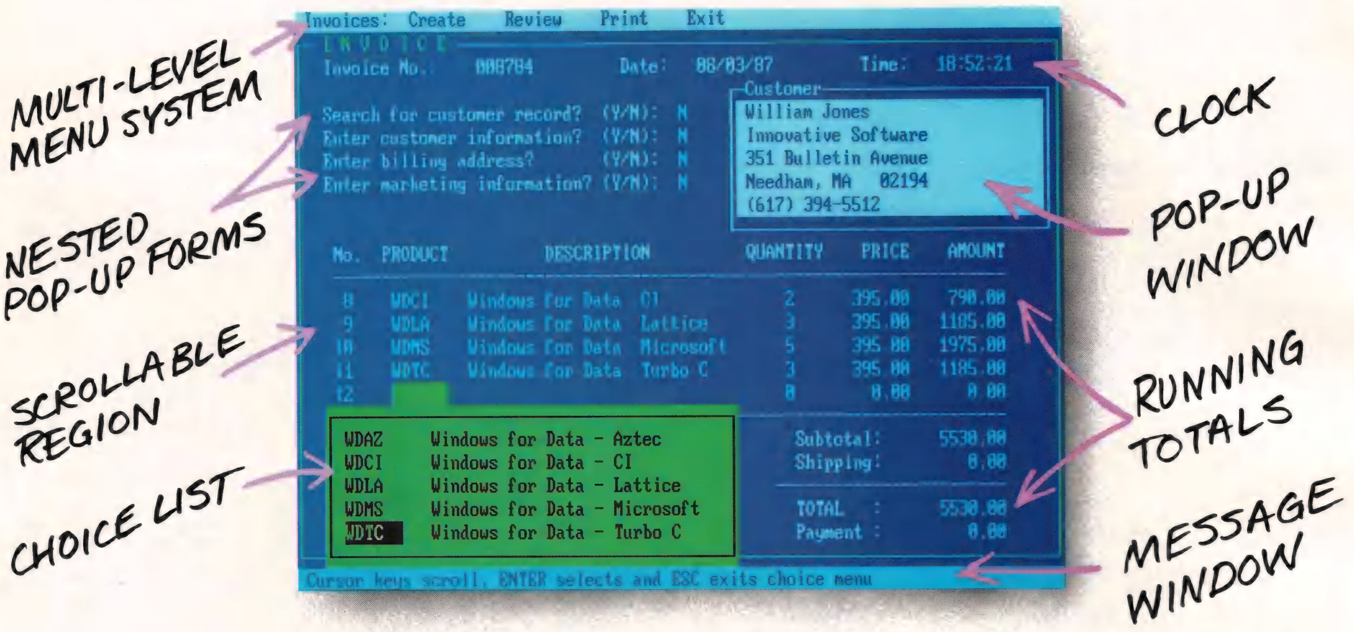

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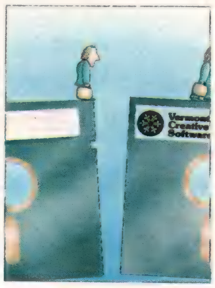

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(continued from page 55)

You'll note that the routine calls an *EXTERN Hhand1__*. Naturally, you must name your high-level handler *Hhand1( )* so that the linker can find it. The *1* in the name allows you to place several versions—*Lhand1( )*, *Lhand2( )*, *Lhand3( )*, and so on—into your library for use in complex programs involving several interrupt handlers. As long as each low-level handler calls its proper high-level partner, there isn't any confusion.

As you will see in the next section, the power of this strategy depends upon having the call to the high-level handler immediately preceded by the push-the-registers statements. If you insist upon setting up your own stack, swap *ss* and *sp* before the *PUSHf* and after the *POPf* so the register stack also serves as the stack for the C routine.

The High-Level Handler

The design of the high-level handler depends on an interesting feature of the C language: setting up the stack before, and cleaning up the stack after a function call, are the responsibilities of the calling routine, not of the function itself. C does this, I gather, to allow for the passing of a variable number of arguments. One secondary consequence of this design is that your higher-level function can be fooled into treating the stack it inherits as if it contained function arguments. Thus, if you give your C code handler a fake argument such as:

```
Hhand1(fake)
   int fake;
{. . .}
```

the compiler will treat the 2-byte region containing the pushed value of the *ax* register as though it were an integer that had been passed to the function. In effect, the entire stack of pushed register values becomes available to the high-level handler as an automatic variable.

If within the handler you declare:

```
typedef struct {
   int ax,bx,cx,dx,di,si,bp,ds,es,flags:
                                   int;
} REGS;
REGS *regs;
```

and then initialize *regs* to point to the base of the stack:

```
regs = &fake;
```

the stack is mapped to that structure. (In practice, of course, this structural definition would be handled globally with an *#include* statement.)

Want to set *dx* on the stack to 0? Write *regs->dx = 0;* without leaving C. After the higher-level routine is exited and the low-level routine *POP*s the stack it had *PUSH*ed, the original calling routine will see a return of 00 in *dx*. It doesn't matter what the C routine has done to the actual value of *dx* in the meantime, because upon *POP*ping the registers, the low-level routine will restore the old values—unless some purposeful changes have been made to the virtual structure **regs*.

The value of this ploy becomes clearer with a specific example. Suppose you wish to write a resident program that captures interrupt *16h*

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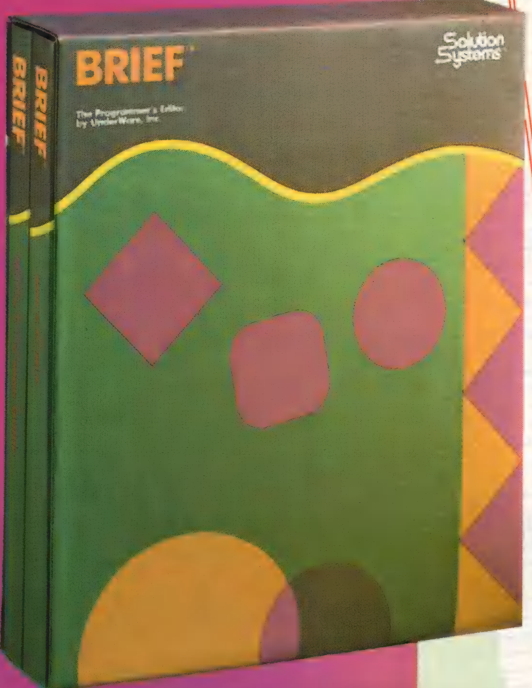

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(continued from page 57)

and checks for five different hot keys that trigger five alternative routines. You would put a long pointer to *Lhand1()* in the place of *int 16h* in the interrupt table and move the old *int 16h* vector out at *NEW16*. The higher-level routine could be written as in Listing Two, page 100.

This, I submit, is considerably easier to write and maintain than an equivalent assembly-language routine full of *CMPs*, labels, and leapfroggings.

The Interrupt Function

With luck, your particular version of C offers an "interrupt" function that permits the stack manipulations described in the previous section. The requirements are:

- the use of a pointer-to-a-register-structure as an argument for the calling function
- the inclusion of all data-bearing registers (including a separate "flag" integer) in that structure
- the potential for using a single memory region as both **inregs* and **outregs*, to use the old Lattice *int86()* terminology. In this case all you need to do is be sure to *PUSH* and *POP* the registers in the low-level handler in exactly the order ordained by the function definition you have inherited.

If, as seems likely, your compiler has made other choices, you can find a suitable version for assembling in Listing Three, page 100. There is probably no need to analyze the code at length, except to observe that the version offered assumes 32-bit pointers and a need to preserve *ds* and *bp* across the function call. Anyone who will profit from automating interrupt handling will be able to check his or her own compiler's assembler output and modify the base pointer addressing to fit the brand and the memory model at hand. The basic strategy is to load the registers from the structure pointed at, make the call in question, reload the structure with the returning values in the registers, and exit.

It is worth noting that the interrupt function in Listing Three has the added virtue of being reentrant —which can be significant if you're capturing more than one interrupt vector in a resident program. Earlier drafts of this system broke down because I tried *movsb*ing parts of the stack back and forth to the global array used by my compiler's interrupt function. Why not adapt the situation, I reasoned, to the ready-made function? Things went swimmingly in simple hot-key routines. When I used the clock interrupt to poll the DOS-is-interruptable flag given by interrupt *21h* service *34h*, however, the register stacks for various interrupts began to corrupt one another 18.2 times a second. Moreover, the compiler's routine did not return the raw flags but provided separate carry and zero flag Booleans. I found myself having to *AND* and *OR* the stack to set up the return. It seemed simpler to write my own function.

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INTERRUPT HANDLING
(continued on page 59)

swapping routine is in Listing Four, page 101. It uses *int 21h*, functions *35h* and *25h*, to get and put interrupt vectors. By setting up a standard function that uses the old interrupt number, the new (or chained) interrupt number, and a pointer to the low-level handler, you can carry out the entire process of vector swapping without explicit recourse to assembly language. Notice that the swap routine returns nonzero in *ax* (modify it if *ax* is not your integer-return register) if the chaining interrupt is in use. Such a feature could be useful in a find-an-unused-interrupt routine.

Once again I assume 32-bit pointers and preserve *bp* and *ds*. A small-model C routine would require more explicit loading of segment registers into *ds* before using service *25h*. In any case, the name of the low-level interrupt handler (in this case, *Lhand1*) is used as the final function argument because C compilers treat a function name by itself as a function pointer—32- or 16-bit—depending on the memory model.

Setting Things Up

If the four functions I've discussed have been compiled and stored in an object file library, setting up a resident program is scarcely more complicated than the writing of the handler code itself. Listing Five, page 102, provides a template for initializing a generic resident program. For clarity's sake I capture a single interrupt; however, there is no limit to the number of vectors that can be inserted into the table with multiple *chgint( )*s. Certainly, in production software the error-handling would be more complex.

To estimate the program size, I ordinarily use interrupt *21h*, service *51h*, to obtain the PSP address of the C program, then subtract that number from the paragraph address of the top of the static heap —plus a couple more paragraphs just to be on the safe side.

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(Listings begin on page 100.)

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by Jim Howell

. . . if things had to be identical before you could recognize them, you would never recognize anything at all. . . . The fact is that our ability to work and to act in the real world depends on our accepting a "tolerance" in our recognition and in our language.
—Jacob Bronowski, A Sense of the Future

Much of the art of communication relies on the ability to differentiate what is meant from what is said. This goes far toward explaining why I have so much trouble at the keyboard; computers have none of the tolerance that a bad (and slightly dyslexic) typist such as myself needs. My computer doesn't understand that "dri" means "dir," so it yells "Bad command or file name," then sits there, waiting for something intelligible.

To you and me, it's obvious what command I actually meant, but to the computer, lacking the recognition tolerance shaped by millions of years of evolution, the input is gibberish. As simple as this example seems, it has proved a difficult problem to solve through some mechanism that a computer can use efficiently. In spite of the time and effort that have gone into attempts to solve this problem (the venerable Soundex algorithm dates from World War I), no wholly satisfactory solution has yet come to light.

But that isn't to say that there haven't been gains on the problem. In fact, another promising solution has recently arisen that is certainly worth passing on, warts and all. The algorithm comes from Michael Bickel and was published in the March issue of the *CACM*.[1]

The method is simple—each letter has a weight associated with it. The "likeness score" between two words is calculated by summing the weights of all the letters in common between the two words, each letter being counted only once. Letters are converted to uppercase, and numbers, punctuation, and white space are ignored. The method can be easily made sensitive to case or to consider numbers.

The weights are based on the frequencies of the letters, being the negative of the logarithm (base 2) of the frequency of the letter (the frequencies sum to 1.0). This gives greater weight to the less common letters. Bickel's weights are given in Table 1, below.

Weight	Letters
3	a e i n o s t
4	d h l r u
5	c f g m p w
6	b v
7	k q
8	j, x, y
9	z
0	all others

***Table 1:** Letter weights used in Bickel's algorithm*

Bit	7	6	5	4	3	2	10
Byte 0	–	a	e	i	n	o	st
Byte 1	–	–	–	d	h	l	ru
Byte 2	–	–	c	f	g	m	pw
Byte 4	b	v	k	q	j	x	yz

***Table 2:** Positions in the letter set*

As an example, say you want to match the word *ecdysiast*. You first create a set (I call this a letter set; Bickel uses the name *MASK*)—*acdeisty*—from the letters in the word. Now consider the word *ecstasy*, which has the letter set *acesty*. To compare these, take the intersection of the two sets—namely, *acesty*. The first letter in the new set is *a*. The weight of this letter is 3, so the likeness score is set to this. The next letter is *c*, so you add 5 to the score. Then add 3 for *e*, 3 for *s*, 3 more for *t*, and 8 for *y* to give a likeness of 25.

To compare *ecdysiast* to *ectoplasm*, you form the letter set *acelmopst*. The intersection with the set of *ecdysiast* is *acest*, and so the likeness score of these two words is only 17. If you were to transpose two letters and compare *edcysiast*, say, the likeness scores would still be 25 and 17. The score of comparing *ecdysiast* and *edcysiast* would be 32, however, so *ecdysiast* becomes the word to look at more closely.

Implementation

Bickel illustrated the algorithm using NOMAD2 (a fourth-generation language), but it can just as easily be implemented in C using a bit set with 26 members. For each word, set the appropriate bit for each letter, leaving the rest unset. Then combine the two sets with a logical AND. Only the common letters are left in the combined set, which are then added using the appropriate weights.

You can do this in several ways. I chose to use a 4-byte array (of type *unsigned char*) to hold the letter set. A static data array, which is indexed by

Jim Howell, 45 Lodgepole Dr., Evergreen, CO 80439. Jim is a former geologist who now works as a programmer for Reference Technology in Evergreen.

lowercase letters, is initialized with the index to the appropriate byte in the letter set array along with the mask necessary to set the correct bit (see Listing One, page 110). The letter set array is designed so that the first three bytes have common weights, with the rest being stuffed into the fourth byte (see Table 2, page 54).

To construct the letter set for a word, go through the word character by character. If the character is a letter, convert it to lowercase and use this as an index into the data array to set the appropriate bit in the letter set array. Duplicate letters result in needless repetition; once a bit is set, setting it again doesn't do any good, but any scheme to avoid setting an already set bit would have too much overhead, so the problem, such as it is, is ignored.

Calculating the likeness score from the two letter sets is straightforward. The first three bytes use a common algorithm. Combine the appropriate bytes from the two letter sets into a mask with a logical AND; then examine the rightmost bit of the resulting byte, and if it is set, increase the likeness score by the appropriate weight; and finally, shift the mask to the right one bit and examine the rightmost byte, and so on through the bits, using a *for* loop.

The fourth byte is more complicated because its letters have different weights. The easiest solution is to operate on each bit individually, in effect hard-wiring the weights. Speed is most important here, space and elegance less so.

As an example, let's search the set of keywords in Table 3, right, using several common (for me) misspellings of *geochemistry.* Using *geochemsitry* (*s* and *i* transposed), the highest likeness scores are:

geochemistry	(46)
biochemistry	(41)
geochronometry	(40)
geothermics	(38)
geophysical	(34)

A search with another misspelling *geochemistru* (*u* mistyped for *y*)—gives:

geochemistry	(38)
geothermics	(38)
biochemistry	(33)
geochronometry	(32)
geochemical	(28)

And using *geochemistr* (*y* dropped), you have:

geochemistry	(38)
geothermics	(38)
biochemistry	(33)
geochronometry	(32)
geochemical	(28)

If the search word is simply *chemsitry* (with the transposition), the best matches are:

geochemistry	(38)
biochemistry	(38)
geochronometry	(32)
geothermics	(30)
geophysical	(26)

The last three examples point out the main weakness of this method: letter order is not significant. To us, *geochemistr* is nothing like *geothermics,* but the method is too simple to detect this. Other algorithms can check for transpositions, or altered letters, or dropped letters,[2] but because of combinatorial complexities, these can be slow. The strength of Bickel's algorithm lies in its simplicity, which in practice means speed. It can be used as a first pass to select likely candidates for the slower routines.

Limitations

Bickel's algorithm has some trouble with short words, especially if the letters are high-frequency ones. Such a word could match a great many other words—a major problem if a given word list is long. In fact, any word composed of frequent letters behaves in this way, no matter what the length. The longer the list to be searched, the greater the problem.

As an example, a search of the keyword list using *meter* gives:

geochemistry	(15)
geothermics	(15)
geochronometry	(15)
biochemistry	(15)
geothermal	(15)
geometry	(15)

In a long word list, the search should be restricted—for example, by assuming that the first letter is correct. Even this may not be enough, as with *George:*

geomorphology	(15)
geochemistry	(15)
geochronology	(15)
geochronometry	(15)
geopressure	(15)
geographic	(15)
geothermal	(15)
geothermics	(15)
geometry	(15)

Here additional criteria, such as having the lengths of the words be "close," could be profitably used to narrow down the search.

geochemical
geochemistry
geochronology
geochronometry
geodesy
geographic
geologic
geological
geomac
geometry
geomorphology
geophysical
geophysics
geopressure
geothermal
geothermics
biochemistry

Table 3: *Keywords taken from a reference list.*

Thoughts on Optimization

In a real application of this algorithm, you would probably want to build it for speed, which will mean a bout with the assembler. But preplanning can help. If there are only a handful of words in the list to be searched, any savings in time will likely be too small to be noticed by the user. Also, you could save some time by constructing the letter sets in advance so that speed wouldn't be as important. Fast code is most essential when there is a large list to search and in interacting with an impatient user.

For a fast assembler routine, I would unfold all the loops, making the code bulky but avoiding all the overhead of incrementing and comparing the counter. The masks and weights would be built in as immediate data, again sacrificing space for speed. Order is not important here, so by putting the least common letters at the end, it would be possible to check for an empty set and return

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SOUNDEX ALTERNATIVE
(continued from page 63)

early from the function if there was nothing more to check.

It is possible to save some space and a little speed by eliminating the two most common letters, *e* and *t*. The letter set could then be stored in three bytes, and two nearly inevitable comparisons could be eliminated from the likeness calculation.

Comparison with the Soundex Algorithm

The Soundex algorithm is a creaking ancient by computer standards, but because it is still widely used, it is worth comparing it with Bickel's new algorithm. To review (or introduce) it, the Soundex algorithm constructs a code by preserving the first letter of a name. From the rest, eliminate all vowels and the letters *h* and *w* along with all doubled letters (keeping one of them). The remaining letters (except the first) are replaced with numbers. The key is the initial letter and the first three numbers of the rest of the name, padded with 0s if necessary.[3]

The main advantage the Soundex algorithm has over Bickel's is that the computation is done only once per word. The key is more like a hash function in that it is usually arbitrary and there is no good way to compare two values. Bickel's algorithm requires a set of calculations at each comparison but does a good job of indicating the amount of similarity.

Notes

1. Michael Allen Bickel, "Automatic Correction to Misspelled Names: A Fourth-Generation Language Approach," *CACM* 30 (March 1987): 224–228.
2. Dave Taylor, "Wordz That Almost Match," *Computer Language* 3 (November 1986): 47–59.
3. Donald E. Knuth, *The Art of Computer Programming, Volume 3: Searching and Sorting* (Reading, Mass.: Addison-Wesley, 1973): 391–392.

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(Listing begins on page 98.)

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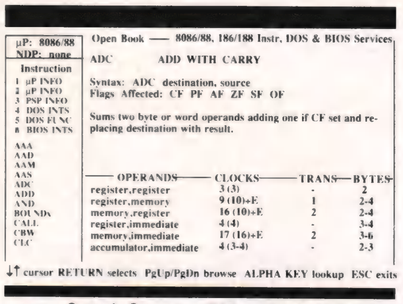

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2 µP INFO     Syntax:  ADC  destination, source
3 PSP INFO    Flags Affected:  CF  PF  AF  ZF  SF  OF
4 DOS INTS
5 DOS FUNC    Sums two byte or word operands adding one if CF set and re-
6 BIOS INTS   placing destination with result.

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AAM
AAS           —— OPERANDS——————— CLOCKS——————TRANS——BYTES
ADC           register,register        3 (3)        -       2
ADD           register,memory          9 (10)+E     1       2-4
AND           memory,register          16 (10)+E    2       2-4
BOUNDs        register,immediate       4 (4)        -       3-4
CALL          memory,immediate         17 (16)+E    2       3-6
CBW           accumulator,immediate    4 (3-4)      -       2-3
CLC

↓↑ cursor RETURN selects  PgUp/PgDn browse  ALPHA KEY lookup  ESC exits
```

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CIRCLE 354 ON READER SERVICE CARD

Listing One *(Text begins on page 18.)*

```
/*------------------------------------------------------------------
        main.c
        Program skeleton for testing the contour map algorithm

        This program reads in a MacPaint document, unpacks
        it, and calls the contour analysis algorithms.

        Once the analysis is complete the program writes out a
        file called grid.dat that can be read by hidlinpix and
        displayed in 3D perspective with hidden lines removed.

        hidlinpix is a program published in "Programming
        Principles in Computer Graphics" by Leendert
        Ammeraal (John Wiley & Sons, 1986)

        Other notes:

        Data structure libraries are derived from Alan Holub's
        column in Doctor Dobb's Journal.  These include the AVL
        tree and the queue.

        I modified the Lightspeed C stdio library so that the stdio
        console window occupies only the lower 1/3 of the screen.
        I then use the upper 2/3 for a window to display the source
        contour map and a second window to display the progress of the
        algorithm.

        William May
        303A Ridgefield Circle
        Clinton, MA 01510

        Jan 25, 1986        created
 ------------------------------------------------------------------*/

#include <stdio.h>
#include <WindowMgr.h>
#include "contour.h"

TREE                *root = 0L;
WindowPtr left_wind;
WindowPtr right_wind;
BitMap              bmap;
curve_data          curves[100];            /* array of curve data */

main()
{
        char c;
        Rect r;
        int width;

        /* force the LSC stdio window to open by doing a printf */
        printf("Program Starting\n\n");

        /* suppress the LSC dialog window when the program ends */
        Click_On(false);

        /* open some windows... */
        init_windows();

        init_mem();

        /* read in the MacPaint document, named "test" */
        if (read_MP("\ptest", &bmap)) {
                r.top     = 0;
                r.bottom  = VBITMAX;
                r.left    = 0;
                r.right   = HBITMAX;
                show_bmap(left_wind, &bmap, &r);

                find_all_contours();
        }

        make_hidlin();       /* make the input file for hidlinpix */

        /*
           A "real" program should return allocated memory to the
           system here, etc.  I will just return and let the heap
           reinitialization take care of everything.
        */

        printf("Program complete. <cr> to continue: ");
        c = getchar();
}

/*------------------------------------------------------------------
        init_windows opens the two windows used for testing graphics
        algorithms.  The console window is opened automatically
        by stdio when a printf is called.  No window template resources
        are used.  The two window records are kept in application global
        space.
 ------------------------------------------------------------------*/
init_windows()
{
        static WindowRecord left_wrec, right_wrec;
        int height, width;
        Rect r;

        height = 180;
        width  = 144;

        r.top    = 22;
        r.left   = 20;
        r.bottom = r.top + height;
        r.right  = r.left + width;

        left_wind = NewWindow(&left_wrec, &r, "\p", true, altDBoxProc,
                        FrontWindow(), false, 0L);

            r.left = 184;
            r.right = r.left + width;

            right_wind = NewWindow(&right_wrec, &r, "\p", true, altDBoxProc,
                        FrontWindow(), false, 0L);
    }
```

End Listing One

Listing Two

```
/*
            global.h

            contains the external references to global variables
*/

extern  TREE                    *root;              /* root of AVL tree */
extern  WindowPtr     left_wind;
extern  WindowPtr     right_wind;
extern  BitMap                  bmap;                              /* bitmap being
                                                                          used */
extern     curve_data           curves[100];             /* array of curve data */
```

End Listing Two

Listing Three

```
/* ----------------------------------------------------------------------
 *          contour.h
 *
 *          defines the leaf structure and does the usual includes
 * ---------------------------------------------------------------------- */

#include <WindowMgr.h>

typedef struct {
            union {
                        long key;               /* key = h,v concatenated */
                        Point p;
            } header;
            int  curve;             /* curve that this point is on */
} LEAF;

#define HBITMAX 576  /* max pixels in horiz direction */
#define VBITMAX 720 /* max pixels in vert direction */

#include "tree.h"

typedef struct curve_data {
            Point       p;                                   /* starting point of curve */
            int                         parent;              /* parent (enclosing) curve */
            int         elevation;                           /* elevation of the curve */
            int         searched;                            /* has interior been
                                                                           searched? */
} curve_data;
```

End Listing Three

Listing Four

```
/*----------------------------------------------------------------------
            tracer.c

            There is only one externally visible function: find_all_contours

            Implements contour search and tracing algorithms
            Some sections are based on Pavlidis, "Algorithms for Graphics and
            Image Processing"

            Quick description: the algorithm examines the interiors of known
            contours to find additional contours.

            It is started by treating the border of the image itself as a contour.

            The final outcome of this algorithm is a tree containing all points
            on contours in the image.  The key for a leaf in the tree is the point
            coordinates.  Each leaf also contains an index for the contour containing
            the point, and the elevation for the point.

            William May

            created             Jan 31, 1987
            modified  Apr 10, 1987          improve the trace logic to handle
                                contours that are multiple pixels in
                                thickness.
  ----------------------------------------------------------------------*/


#define DEBUG

#ifdef DEBUG
#define D(x)        x
#else
#define D(x)
#endif

#include <QuickDraw.h>
#include <MemoryMgr.h>
#include <stdio.h>
#include "getpixel.h"
#include "contour.h"
#include "global.h"

/* two defines for our trace directions */
#define CLOCKWISE -1
#define COUNTERCLOCKWISE 1

/* the index of the image borders is BASE (the exterior contour) */
#define BASE        -1

/* define the queue elements */
typedef struct {
            int h, v, chain;
} q_item;
```

(continued on next page)

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CIRCLE 309 ON READER SERVICE CARD

Listing Four *(Listing continued, text begins on page 18.)*

```
static char *qp;                        /* pointer to the queue */
static int          qmax = 0;           /* max items in the queue */

static int current_elevation = 0;       /* current elevation of region */
static int next_curve = 0;              /* number of next index in curve array */

static long point_count;                /* count the points we have found */

/*----------------------------------------------------------------
          find_all_contours finds all the contours in a bitmap
          first the left side of the bitmap is entered into the queue to
          start off the search.  then each time find_contours returns
          (meaning no more contours at that level) the elevation is incremented
          for the next round of searches.
  ---------------------------------------------------------------*/
int find_all_contours()
{
          char ch;
          Point pt;
          GrafPtr old_port;
          int draw_point();
          int item;
          register int i;
          char *makequeue();

          qp = makequeue(4000, sizeof(q_item));

          start_queue();                              /* set up search for exterior of bitmap */

          find_contours(BASE);                        /* find the first level of contours */
                                                      /* parent = -1 */

          while (next_point(&item, &pt)) {            /* while there is an unsearched curve */
                    trace(pt, COUNTERCLOCKWISE, true);  /* set up queue for next search */
                    find_contours(item);              /* go get 'em. item = parent */
          }

          free(qp);                                   /* all done, get rid of the queue */

          set_elevations();                           /* set elevations in the array */

          printf("max used in queue is %d\n", qmax);
          printf("number of curves found is %d\n", next_curve);
          printf("number of points found is %ld\n", point_count);
          printf("Curve search complete. <cr> to continue: ");
          ch = getchar();

          GetPort(&old_port);
          SetPort(right_wind);
          EraseRect(&(right_wind->portRect));
          D(printf("Now traversing the tree.\n"));
          D(traverse(root, draw_point));

          SetPort(old_port);
}

/*----------------------------------------------------------------
          start_queue puts the left edge of the bitmap into the
          queue to act as start for the bitmap search

          only the left edge needs to be put in because the other edges
          would be ignored anyway
  ---------------------------------------------------------------*/
static start_queue()
{
          register int i;
          q_item q;

          q.h = 0;
          q.chain = 6;                    /* all starting queue items are going south */

          for (i = 0; i < VBITMAX; i++) {
                    q.v = i;
                    if (!enqueue(&q,qp))
                              syserr(0, "Queue overflow in startup function\n");
          }
}

/*----------------------------------------------------------------
          set the next curve starting point if there is one,
          otherwise return 0;
  ---------------------------------------------------------------*/
static int next_point(item,pt)
int       *item;
Point     *pt;
{
          static int last_searched = -1; /* last array index used */

          if (++last_searched < next_curve) {
                    *item = last_searched;
                    pt->h = curves[last_searched].p.h;
                    pt->v = curves[last_searched].p.v;
                    return 1;
          }
          else
                    return 0;
}

/*----------------------------------------------------------------
          set the elevations in the array
          assume all contours are ascending
          and increment = 100
  ---------------------------------------------------------------*/
set_elevations()
{
          register curve_data *p = curves;
          register int parent, i;

          for (i = 0; i < next_curve; i++, p++) {
                    if ((parent = curves[i].parent) == BASE)
                              curves[i].elevation = 100;
                    else
                              curves[i].elevation = curves[parent].elevation + 100;
          }
}

/*----------------------------------------------------------------
          find_contours searches for all contours within a closed contour,
          based on the queue elements
          if any are found a non-zero value is returned
  ---------------------------------------------------------------*/
static int find_contours(parent)
int parent;                                       /* index of enclosing curve */
{
        q_item item, *show_next();
        register int c;
        Point p;
        int B, next_chain;
        Point first, last;

        while (dequeue(&item, qp)) {
                c = item.chain;

                if (c == 8) {
                        dequeue(&item, qp);
                        c = item.chain;
                }

                if ((c >= 5 && c <= 7) ||
                        (c == 0 && ((next_chain = (*show_next(qp)).chain) >= 5) &&
                        (next_chain <= 7))) {
                                p.h = item.h + 1;
                                p.v = item.v;

                                D(first = p);

                        do {
                                search_x(&B, &p);

                                if (B == 1) {

                                        D(last = p);
                                        D(show_line(first, last));

                                        /*
                                                if trace found a new contour then break off
                                                the scan.  If the point is a new point on a
                                                known contour, then continue.

                                        */
                                        if (trace(p, CLOCKWISE, false)) {
                                                /* and add curve to array */
                                                curves[next_curve].p = p;
                                                curves[next_curve].parent = parent;
                                                curves[next_curve].elevation = 0;
                                                curves[next_curve].searched = false;
                                                next_curve++;
                                                break;
                                        } else
                                                p.h++;    /* bump up to next point */
                                }
                                else if (B >= 2) {
                                        D(last = p);
                                        D(show_line(first, last));
                                        break;
                                }
                        } while (1);
                }
        }
        return 1;
}

/*----------------------------------------------------------------------
        scan pixels in the x direction at point p
        if the bitmap shows a pixel return 1
        if the bitmap shows a pixel and the pixel is in the tree
        (i.e. the point has been scanned before) return 2
        update the starting point
  ---------------------------------------------------------------------*/
static search_x(b, p)
int *b;
Point *p;
{
        long dcmp();
        /*
                the union makes it easy to use the point coordinates
                as the key in the tree
        */
        union {
                Point pt;
                long  key;
        } q.

        q.pt = *p;

        if (*b = getpixel(q.pt.h, q.pt.v, &bmap)) {
                if (find(root, q.key, dcmp)) (*b)++;
                return;                                 /* don't increment h on a hit */
        }

        if (++p->h >= HBITMAX) {
                *b = 2;                         /* when we hit the right edge,indicate already
                                                                                        found */

                return;
        }
}

/*----------------------------------------------------------------------
        trace traces a contour beginning at the specified point
        at each found point the x,y coordinates and chain code are
        stored both in the queue and the tree.

        two result codes are returned:
        0 indicates that the starting point represented a new point on an
          existing (known) contour.  trace was aborted.
        1 indicates a new contour was successfully traced
  ---------------------------------------------------------------------*/
static int trace(p, dir, q_only)
Point p;                /* p is the starting point */
int dir;                /* dir is the trace direction */
Boolean q_only; /*  trace and put in queue only,
                                                do not check for dupes in tree */
{
        Point c, t;             /* current point, and transformed point for testing */
        int s;      /* search direction */
        Boolean found, test_pixel();
        int count, used, chain;
        q_item item;
        LEAF *lp, *lp2;
        long icmp(), dcmp();
        GrafPtr old_port;
        union temp {
                long key;
                Point p;
        } temp;

        if (dir == COUNTERCLOCKWISE)
                s = 6;
        else
                s = 2;

        c = p;
```

(continued on next page)

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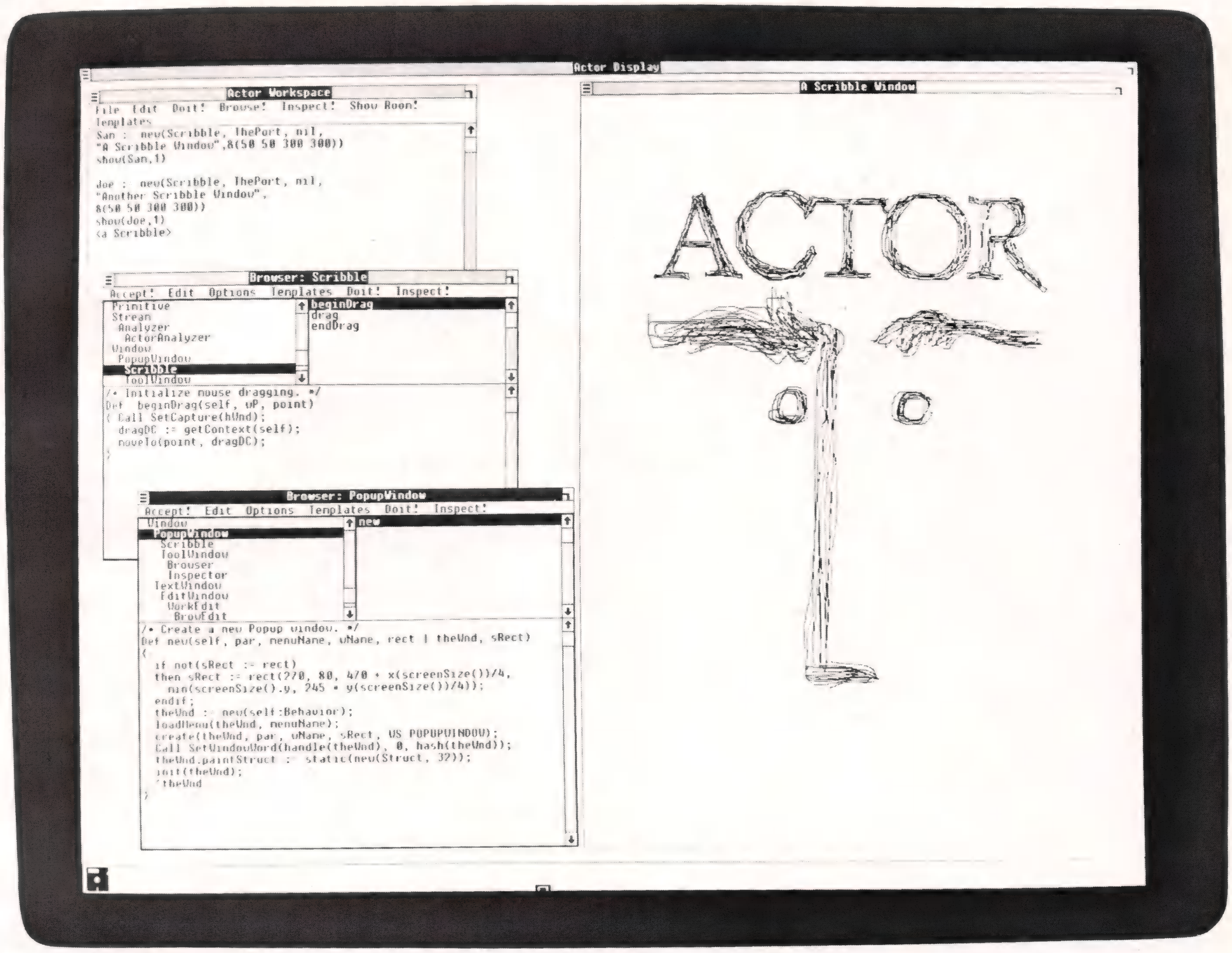
CIRCLE 313 ON READER SERVICE CARD

Listing Four *(Listing continued, text begins on page 18.)*

```
if (q_only) {
        /* has this curve interior been searched before? */
        temp.p.h = c.h;
        temp.p.v = c.v;
        lp = find(root, temp.key, dcmp);

        if (curves[lp->curve].searched == true) {
                printf("Curve %d already searched\n", lp->curve);
                return 0;
        }
        else
                curves[lp->curve].searched = true;

        item.h = c.h;           /* add data to queue */
        item.v = c.v;
        item.chain = 8;         /* mark beginning of new contour */
        if (!enqueue(&item,qp))
                syserr(0, "Queue overflow in trace\n");

        GetPort(&old_port);
        SetPort(right_wind);
        PenPat(white);
        SetPort(old_port);
}
else {
        if (!(lp = talloc(sizeof(LEAF))))
                syserr(MemErr, "Insufficient memory for AVL tree");
        else {
                lp->header.p.h = c.h;
                lp->header.p.v = c.v;
                lp->curve = next_curve;

                if (lp2 = insert(&root, lp, icmp)) {
                        /* tfree(lp); not implemented in getmem! */
                        return 0; /* starting point already in the tree !! */
                }
                else {  /* if not in the tree then enqueue the new point */
                        point_count++;

                        item.h = c.h;           /* add data to queue */
                        item.v = c.v;
                        item.chain = 8;         /* mark beginning of new contour */
                        if (!enqueue(&item,qp))
                                syserr(0, "Queue overflow in trace\n");

                        GetPort(&old_port);
                        SetPort(right_wind);
                        PenPat(black);
                        SetPort(old_port);
                }
        }
}


do {
        found = false;
        count = 0;
        while (!found && (count < 3)) {
                count++;
                if (test_pixel(c, add_chain(s, -1 * dir))) {
                        set_pixel(&c, (chain = add_chain(s, -1 * dir)));
                        s = add_chain(s, -2 * dir);
                        found = true;
                }
                else {
                        if (test_pixel(c, s)) {
                                set_pixel(&c, (chain = s));
                                found = true;
                        }
                        else {
                                if (test_pixel(c, add_chain(s, 1 * dir))) {
                                        set_pixel(&c, (chain = add_chain(s, 1 * dir)));
                                        found = true;
                                }
                                else
                                        s = add_chain(s, 2 * dir);
                        }
                }
        }
        D(show_point(c));

        if (q_only) {
                item.h = c.h;           /* add data to queue */
                item.v = c.v;
                item.chain = chain;
                if (!enqueue(&item,qp))
                        syserr(0, "Queue overflow in trace\n");
        }
        else {
                if (!(lp = talloc(sizeof(LEAF))))
                        syserr(MemErr, "Insufficient memory for AVL tree");
                else {
                        lp->header.p.h = c.h;
                        lp->header.p.v = c.v;
                        lp->curve = next_curve;

                        if (lp2 = insert(&root, lp, icmp)) {
                                /* tfree(lp); not implemented in getmem! */
                                if ((c.h == p.h) && (c.v == p.v))
                                        return 1; /* we have returned to the start */
                                else
                                        return 0;
                        }
                        else {                          /* if not in the tree then enqueue point */
                                point_count++;

                                item.h = c.h;           /* add data to queue */
                                item.v = c.v;
                                item.chain = chain;
                                if (!enqueue(&item,qp))
                                        syserr(0, "Queue overflow in trace\n");
                        }
                }
        }
        if ((used = sp_used(qp)) > qmax) qmax = used;
} while ((c.h != p.h) || (c.v != p.v));

GetPort(&old_port);
SetPort(right_wind);
PenPat(black);
SetPort(old_port);
        return 1;
}
```

(continued on page 72)

HOW TO WRITE A WINDOWS APPLICATION IN TEN MINUTES.



```
Sam := new(Scribble, ThePort, nil,
"A Scribble Window",&(50 50 300 300))
show(Sam,1)

Joe := new(Scribble, ThePort, nil,
"Another Scribble Window",
&(50 50 300 300))
show(Joe,1)
<a Scribble>
```

```
/* Initialize mouse dragging. */
Def  beginDrag(self, wP, point)
{ Call SetCapture(hWnd);
  dragDC := getContext(self);
  moveTo(point, dragDC);
}
```

```
/* Create a new Popup window. */
Def new(self, par, menuName, wName, rect | theWnd, sRect)
{
  if not(sRect := rect)
  then sRect := rect(270, 80, 470 + x(screenSize())/4,
    min(screenSize().y, 245 + y(screenSize())/4));
  endif;
  theWnd := new(self:Behavior);
  loadMenu(theWnd, menuName);
  create(theWnd, par, wName, sRect, WS_POPUPWINDOW);
  Call SetWindowWord(handle(theWnd), 0, hash(theWnd));
  theWnd.paintStruct := static(new(Struct, 32));
  init(theWnd);
  ^theWnd
}
```

Actor™ is a new language that combines Microsoft® Windows with object-oriented programming. This means you can produce mouse and window applications very quickly.

For example, we created a simple "paint" program, and used it to draw the Actor logo you see on the screen. The whole program only took ten lines and ten minutes. Part of it is in the middle window on the left.

Above, you see the commands that initialized the paint window and made it appear on the screen. Below, some code that's built into Actor, specifying window behavior. Through a process known as "inheritance," it's called into play automatically.

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MICROSOFT WINDOWS

CIRCLE 282 ON READER SERVICE CARD

Listing Four

(Listing continued, text begins on page 18.)

```
/*---------------------------------------------------------------------
          test the s neighbor of point p
  ---------------------------------------------------------------------*/
static Boolean test_pixel(p,s)
Point p;
int s;   /* direction to test */
{
          set_pixel(&p, s);
          return (getpixel(p.h, p.v, &bmap));
}

/*---------------------------------------------------------------------
          set point p to point + chain code s
  ---------------------------------------------------------------------*/

static set_pixel(p, s)
Point *p;
int s;
{
          switch (s) {
                    case 0:
                              (*p).h++;
                              break;
                    case 1:
                              (*p).h++;
                              (*p).v--;
                              break;
                    case 2:
                              (*p).v--;
                              break;
                    case 3:
                              (*p).h--;
                              (*p).v--;
                              break;
                    case 4:
                              (*p).h--;
                              break;
                    case 5:
                              (*p).h--;
                              (*p).v++;
                              break;
                    case 6:
                              (*p).v++;
                              break;
                    case 7:
                              (*p).h++;
                              (*p).v++;
                              break;
          }
}

/*---------------------------------------------------------------------
          add c to chain code s
  ---------------------------------------------------------------------*/
static int add_chain(s,c)
register int s,c;
{
          register int i;

          if ((i = s + c) >= 8)
                    return (i - 8);
          else {
                    if (i < 0)
                              return (i + 8);
                    else
                              return i;
          }
}

#ifdef DEBUG

/*---------------------------------------------------------------------
          The code below is used to display the progress of the contour
          analysis in a Macintosh window.  It is obviously totally
          nonportable.  Fixed point arithmetic is used for scaling the MacPaint
          size document to a much smaller window.  Fixed point is much faster
          floating point, and is often used for two and three dimensional
          graphics on the Mac.  This code is for debugging purposes.
  ---------------------------------------------------------------------*/

/* ratio is used to scale down picture size by 1/4 */
static Fixed ratio = 0x00004000;

/*---------------------------------------------------------------------
          convert a 16 bit integer to fixed point
  ---------------------------------------------------------------------*/
static Fixed int_to_fix(i)
int i;
{
          asm {
                    move.w    i,d0        ; get the number
                    ext.l     d0          ; clear top of d0
                    swap      d0          ; make it a fixed point number,
                                                                  all done
          }
}

/*---------------------------------------------------------------------
          convert a Fixed point number to 16 bit integer
  ---------------------------------------------------------------------*/
static int fix_to_int(i)
Fixed i;
{
          asm {
                    move.l    i,d0        ; get the number
                    add.l     #0xA000,d0; add .5 to number, for rounding
                    swap      d0          ; make the int, ignore upper word of d0

            }
  }

  /*---------------------------------------------------------------------
            draw the point from a LEAF, scaled down to the actual window size
    ---------------------------------------------------------------------*/
  static draw_point(p)
  LEAF *p;
  {
            GrafPtr oldPort;
            Point q;
            Rect r;

            q = p->header.p;

            GetPort(&oldPort);
            SetPort(right_wind);

            r.top    = fix_to_int(FixMul(int_to_fix(q.v), ratio));
            r.left   = fix_to_int(FixMul(int_to_fix(q.h), ratio));
            r.right  = r.left + 1;
            r.bottom = r.top + 1;

            FrameRect(&r);
            SetPort(oldPort);
  }

  /*---------------------------------------------------------------------
            draw the point, scaled down to the actual window size
    ---------------------------------------------------------------------*/
  static show_point(p)
  Point p;
  {
            GrafPtr oldPort;
            Rect r;

            GetPort(&oldPort);
            SetPort(right_wind);

            r.top    = fix_to_int(FixMul(int_to_fix(p.v), ratio));
            r.left   = fix_to_int(FixMul(int_to_fix(p.h), ratio));
            r.right  = r.left + 1;
            r.bottom = r.top + 1;

            FrameRect(&r);
            SetPort(oldPort);
  }

  /*---------------------------------------------------------------------
            draw a line, scaled down to the actual window size
    ---------------------------------------------------------------------*/
  static show_line(first, last)
  Point first,last;
  {
            GrafPtr oldPort;

            GetPort(&oldPort);
            SetPort(right_wind);

            first.v  = fix_to_int(FixMul(int_to_fix(first.v), ratio));
            first.h  = fix_to_int(FixMul(int_to_fix(first.h), ratio));

            MoveTo(first.h, first.v);

            last.v  = fix_to_int(FixMul(int_to_fix(last.v), ratio));
            last.h  = fix_to_int(FixMul(int_to_fix(last.h), ratio));

            LineTo(last.h, last.v);

            SetPort(oldPort);
  }


  #endif
```

End Listing Four

Listing Five

```
/*
          stack.h

          William May
          2/20/87                 created
*/

typedef int *STACK;

/* function prototypes */
extern int          empty       ( STACK * );
                                        /* is anything on the stack? */

extern int          pop         ( STACK * );
extern int          push        ( int, STACK *);
extern STACK *      init_stack( int );
extern void         del_stack   ( STACK ** );        /* remove stack */
extern int                      top_of_stack( STACK * );
                                             /* returns top of stack */
```

End Listing Five

Listing Six

```
/*-----------------------------------------------------------------
          stack.c

          implements a simple stack of integers

          William May
          303A Ridgefield Circle
          Clinton, MA 01510

          2/20/87                 created
  -----------------------------------------------------------------*/

#ifdef DEBUG
#include <stdio.h>
#endif

#include <storage.h>
```

```
typedef struct STACK {
          int max;              /* max items in stack */
          int top;              /* current items in stack */
          int items[];          /* the data */
} STACK;

/* some error codes */
#define FULL  -2
#define EMPTY -1
#define NOERR  0

#ifdef DEBUG

STACK *mystack;

main()
{
          STACK *init_stack();
          int num, c;

          printf("Stack program begun\n");

          if (!(mystack = init_stack(5))) {
                    fprintf(stderr, "Insufficient memory to create stack\n");
                    ExitToShell();
          }

          while( 1 ) {
                    num = c = -1;

                    printf("top              = %d\n", mystack->top);
                    printf("max              = %d\n", mystack->max);
                    printf("top item = %d\n", top_of_stack(mystack));


                    printf("\n<p(op)/s(push)/q(uit)> -> ");
                    while( c != 'p' && c != 's' && c != 'q' )
                              c = getchar();

                    if( c == 's' )
                    {
                              printf("\nenter decimal number -> ");
                              scanf("%d", &num );
                              printf("\npush(%d) returned %d\n",
                                                            num, push(num, mystack));
                    }
                    else if( c == 'p' )
                    {
                              printf( "\npop returned: %d\n", pop(mystack));
                    }
                    else
                              break;
          }

          del_stack(&mystack);

          printf("\nStack program complete\n");
}
#endif

/*-------------------------------------------------------------------
          create the stack
          NULL returned if insufficient memory
 ------------------------------------------------------------------*/
STACK *init_stack    ( items )
int items;
{
          STACK * p;

          if (p = (STACK *)calloc ((sizeof(int) * items + sizeof(STACK)),1)) {
                    p->max = items;
                    p->top = EMPTY;
          }

          return (p);
}

/*-------------------------------------------------------------------
          delete the stack
 ------------------------------------------------------------------*/
void del_stack ( stackptr )
STACK **stackptr;
{
          free(*stackptr);
          *stackptr = 0L;
}

/*-------------------------------------------------------------------
          is the stack empty?
 ------------------------------------------------------------------*/
int empty ( stack )
STACK *stack;
{
          return ((stack->top == EMPTY) ? 1 : 0);
}

/*-------------------------------------------------------------------
          return the top element of the stack and decrement
          the stack pointer
 ------------------------------------------------------------------*/
int pop ( stack )
STACK *stack;
{
          if (empty(stack))
                    return EMPTY;
          else {
                    return (stack->items[stack->top--]);
          }
}
```

(continued on next page.)

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CIRCLE 330 ON READER SERVICE CARD

Listing Six *(Listing continued, text begins on page 18.)*

```
/*-------------------------------------------------------------------
          push an integer onto the stack and increment the stack pointer
  -------------------------------------------------------------------*/
int push (n, stack)
int n;
STACK *stack;
{
          if (++stack->top < stack->max) {
                    stack->items[stack->top] = n;
                    return NOERR;
          }
          else {
                    --stack->top;
                    return FULL;
          }
}

/*-------------------------------------------------------------------
          look at the top of the stack without changing the
          stack pointer
  -------------------------------------------------------------------*/
int top_of_stack( stack )
STACK *stack;
{
          return (stack->items[stack->top]);
}
```

End Listing Six

Listing Seven

```
/*
          make_hidlin.h

          header file for make_hidlin

          William May

          created:  3/21/87
*/

#define MAPWIDTH     576
#define MAPHEIGHT    720
#define INTERVAL     24        /* interval, in pixels, between grid lines */

#define VMAX 31                /* bitmap height/interval + 1 */
#define HMAX 25                /* bitmap width/interval + 1  */
```

End Listing Seven

Listing Eight

```
/*----------------------------------------------------------------------
          make_hidlin.c

          Creates a grid of elevations and then
          input file for the 3D hidden line algorithm (hidlinpix)

          The input file creation process is fully explained in Ammeraal's
          book "Programming Principle in Computer Graphics"

          William May
          303A Ridgefield Cirlce
          Clinton, MA 01510

          created:  3/20/87
  ---------------------------------------------------------------------*/

#include <stdio.h>
#include "make_hidlin.h"
#include "contour.h"

#define SCALE 100.0

int grid[HMAX+1][VMAX+1];
FILE *fp;

/*----------------------------------------------------------------------
          Coordinate creating an input file for hidlinpix
  ---------------------------------------------------------------------*/
make_hidlin()
{
          printf("Beginning make_hidlin\n");

          init_grid();

          make_grid();

          fp = fopen("grid.dat", "w");

          /* convert grid to hidlin input format */
          conv_hidlin();

          fclose(fp);
}

/*----------------------------------------------------------------------
          0 the grid
          this may be unnecessary for a global, but doesn't hurt
          It is however, necessary if the contour analysis is
          done repeatedly without quitting the program
  ---------------------------------------------------------------------*/
init_grid()
```

(continued on page 76

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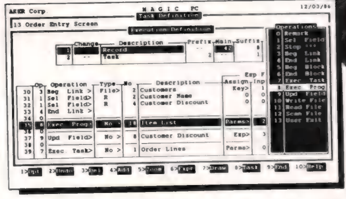

```
AKER Corp.                     M A G I C   PC                          12/03/86
                              Task Definition
13 Order Entry Screen
                           Execution Definition                        Operations
          Change── Description ──────────Prefix─Main─Suffix            0 Remark
       1         Record                     --    42      0            1 Sel  Field
       2    --   Task                        2    --      1            2 Stop ***
                                                                       3 Beg  Link
                                                                       4 End  Link
                                                                       5 Beg  Block
                                                          Exp F        6 End  Block
    Op  Operation  Type  No      Description          Assign Inp       7 Exec  Task
30   3 Beg  Link > File>  2  Customers                  Key>   1       8 Exec  Prog
31   1 Sel  Field>  R     2  Customer Name                0    0       9 Upd  Field
32   1 Sel  Field>  R     4  Customer Discount            0    0      10 Write File
33   4 End  Link >                                                    11 Read File
34   0                                                                12 Scan File
35   8 Exec  Prog>  No >  18 Item List                Parms>   2      13 User Exit
36   0
37   9 Upd  Field>  No >   8 Customer Discount          Exp>   3
38   0
39   7 Exec  Task>  No >   1 Order Lines              Parms>   0

 1>Opt  2>Undo  3>Del  4>Add  5>Zoom  6>Expr  7>Draw  8>Task  9>End  10>Help
```

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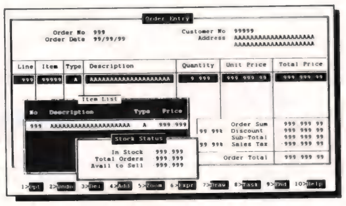

```
                              Order Entry
        Order No   999                     Customer No  99999
      Order Date   99/99/99                    Address  AAAAAAAAAAAAAAAAAAAA
                                                        AAAAAAAAAAAAAAAAAAAA
Line  Item   Type  Description            Quantity  Unit Price   Total Price
 999  99999   A    AAAAAAAAAAAAAAAAAAAA     9 999   999 999 99    999 999 99
               Item List
  No   Description             Type   Price
  999  AAAAAAAAAAAAAAAAAAAA     A    999 999          Order Sum   999 999 99
                                            99 99%   Discount    999 999 99
                    Stock Status                     Sub-Total   999 999 99
                                            99 99%   Sales Tax   999 999 99
               In Stock       999 999
           Total Orders       999 999               Order Total  999 999 99
          Avail to Sell       999 999

 1>Opt  2>Undo  3>Del  4>Add  5>Zoom  6>Expr  7>Draw  8>Task  9>End  10>Help
```

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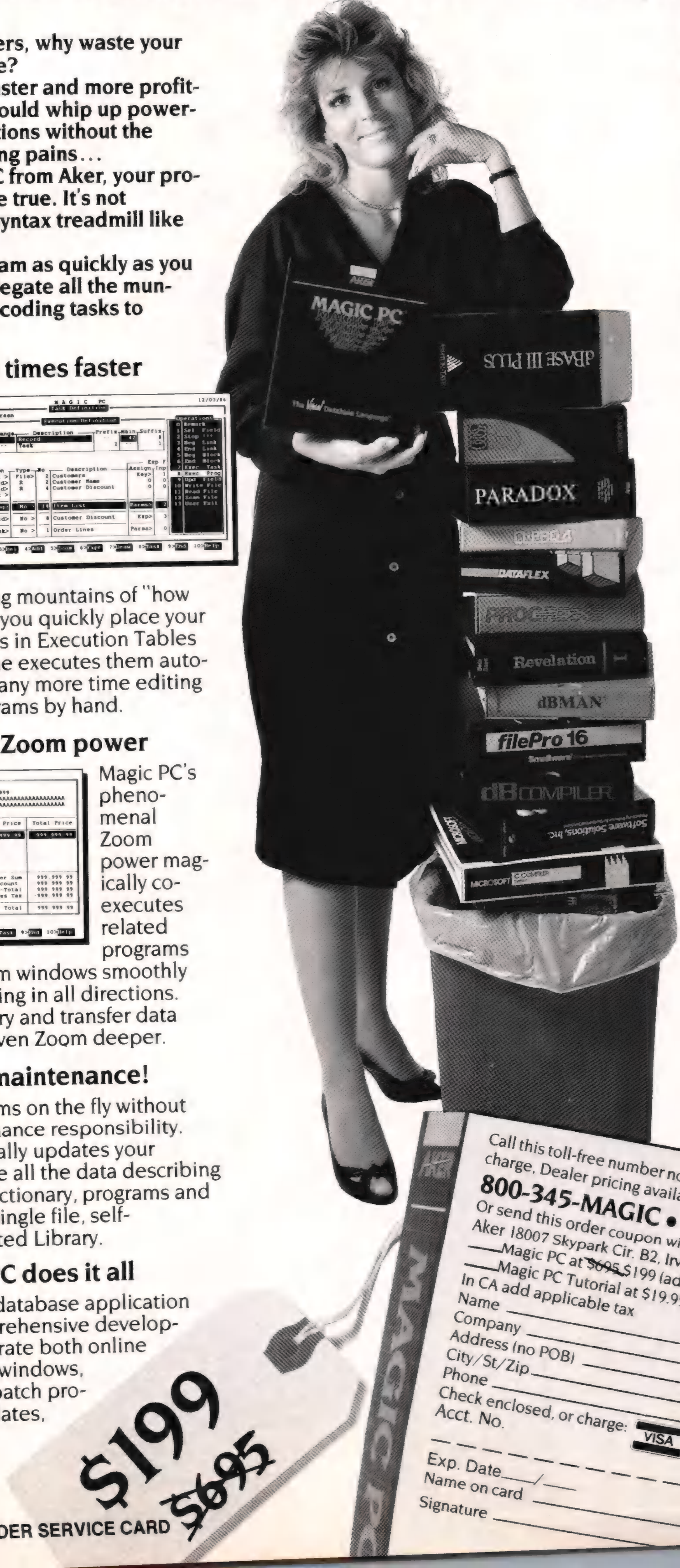

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CIRCLE 392 ON READER SERVICE CARD

Listing Eight *(Listing continued, text begins on page 18.)*

```
{
        register int h,v;

        for (h = 0; h <= HMAX; h++)
                for (v=0; v <= VMAX; v++)
                        grid[h][v] = 0;
}

/*--------------------------------------------------------------------
        Convert the grid to a hidlinpix input file
        This function is based on code from Ammeraal's book for
        doing 3D projections of mathematical functions
 --------------------------------------------------------------------*/
conv_hidlin()
{
        int i, j, k, l;
        double f();

        fprintf(fp, "%lf %lf %lf\n", (double)HMAX / 2.0, (double)VMAX / 2.0, 0.0);

        printf("Printing the point coordinates\n");

        for (i = 0; i <= HMAX; i++) {
                for (j = 0; j <= VMAX; j++) {
                        fprintf(fp, "%d %lf %lf %lf\n", j*(HMAX+1)+i+1,
                                (double)i, (double)j, f(i,j));
                }
        }

        fprintf(fp, "Faces:\n");

        printf("Printing the faces\n");

        /* next two lines switched */
        for (i = 0; i < HMAX; i++) {
                for (j = 0; j < VMAX; j++) {
                        k = j*(HMAX+1)+i+1;
                        l = k+HMAX+1;
                        fprintf(fp, "%d %d %d#\n", k, -(l+1), k+1);
                        fprintf(fp, "%d %d %d#\n", k+1, l+1, -k);
                        fprintf(fp, "%d %d %d#\n", k, -(l+1), l);
                        fprintf(fp, "%d %d %d#\n", l, l+1, -k);
                }
        }
}

/*--------------------------------------------------------------------
        note reversing the h coordinates
        somewhere the grid is being reversed, so I unreverse it here.
 --------------------------------------------------------------------*/
double f(h,v)
int h,v;
{
                . return ((double)(grid[HMAX - h][v]) / SCALE);
}
```

End Listing Eight

Listing Nine

```
/*-------------------------------------------------------------
        make_grid

        converts graph data into a grid that can be interpreted
        by hidlinpix

        William May
        303A Ridgefield Circle
        Clinton, MA 01510

        Feb 16, 1986                    created
 -------------------------------------------------------------*/

#define DEBUG

#ifdef DEBUG
#define P(x) x
#else
#define P(x)
#endif

#include <stdio.h>
#include "stack.h"
#include "make_hidlin.h"
#include "contour.h"
#include "global.h"

extern int stack_error;
extern int grid[HMAX][VMAX];

static STACK *stack;

/*--------------------------------------------------------------
        move vertically
        assigning elevations to each grid point
 --------------------------------------------------------------*/
make_grid()
{
        register int h;

        stack = init_stack(2000);       /* should be plenty! */

        for (h = 1; h < (HMAX-1); h++) {
                traverse_vert(h);
        }

        del_stack(&stack);
}
```

```
/*-----------------------------------------------------------------------
        Traverse a vertical grid line, determining elevations along the way
        This is mostly simple: i.e. keep track of the elevation of the
        contour line crossed last.
        The main complications are tangents (in which case we want to ignore
        the contour line) and inflection points (in which case we don't
        ignore the contour line).
  ----------------------------------------------------------------------*/
traverse_vert(h)
register int h;
{
        register int ver, hor;
        register int vmax = (VMAX - 1) * INTERVAL;

        hor = h * INTERVAL;

        push(0, stack);                 /* push 0 (elev of border) onto the stack */

        P(show_line(hor,1,hor,vmax));

        for (ver = 1; ver < vmax; ver++) {
                /* traverse a vertical grid line */
                /* on a grid intersection set array to value on the stack */
                if (!(ver % INTERVAL)) {
                        P(show_point(hor-3,ver));
                        P(show_point(hor+3,ver));
                        set_elevation(h, (ver / INTERVAL));
                }

                /* are we crossing a contour? are we tangent to it? */
                if (getpixel(hor, ver, &bmap)) {
                        if (is_crossing(hor, ver) || start_inflection(hor, ver))
                                ver += check_hit(hor,ver);
                }
        }
}
/*-----------------------------------------------------------------------
        set grid[h][v] to the value of top of stack
  ----------------------------------------------------------------------*/
static set_elevation(h, v)
register int h, v;   /* note these are grid coordinates !! */
{
        grid[h][v] = top_of_stack(stack);
}
/*-----------------------------------------------------------------------
        a pixel was hit, get the curve index from tree
        get curve elevation from curve array
        if curve elevation = elevation on stack
                pop stack
        else
                push new elevation
        end
        return the number of pixels to skip-1 (i.e.
        return 0 if wskip 1, etc.)
  ----------------------------------------------------------------------*/
static short check_hit(h, v)
register int h, v;   /* note these are pixel coordinates !! */
{
        short     cnt = 1;   /* number of pixels */
        short   ver;

        union temp {
                long key;
                Point p;
        } temp;
        LEAF *lp;
        long dcmp();
        int elev;

        /* traverse all pixels, if more than one */
        for (ver = v+1; getpixel(h, ver++, &bmap); cnt++)
                ;

        temp.p.h = h;
        temp.p.v = v;
        lp = find(root, temp.key, dcmp);

        elev = curves[lp->curve].elevation;

        if (elev == top_of_stack(stack))
                pop(stack);
        else
                push(elev, stack);

        return (cnt-1);
}
/*-----------------------------------------------------------------------
   is_crossing: tests a point on a contour to figure out if
   we are crossing the contour or tangent to the contour.  If we are
   tangent to it we don't want to bump the elevation yet.
   The test is performed by examining the six pixels to the side:
      1       4
           2 h,v 5
           3      6
   Crossings are:
                        two or more hits in range 1-6
                        1+ in 1-3 and 1+ in 4-6
   return false for a tangent, true for a crossing.
  ----------------------------------------------------------------------*/
static int is_crossing(h, v)
int       h, v;
{
        register int h_test, v_test, i;

        h_test = h - 1;       /* test the 1-3 */
```

(continued on next page)

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CIRCLE 166 ON READER SERVICE CARD

Listing Nine *(Listing continued, text begins on page 18.)*

```
        v_test = v - 1;
        for (i = 0; !getpixel(h_test, v_test, &bmap) && i < 3; i++, v_test++)
                ;

        if (i == 3)
                return false;           /* a tangent was hit */

        h_test = h + 1;         /* test the 4-6 */
        v_test = v - 1;
        for (i = 0; !getpixel(h_test, v_test, &bmap) && i < 3; i++, v_test++)
                ;

        if (i == 3)
                return false;           /* a tangent was hit */

        return true;                    /* looks good! */
}

/*-------------------------------------------------------------------------
   start_inflection: tests to see if this point is the start of an
   inflection in the contour. An inflection will not look like a crossing,
   but should be counted as one.
   An inflection looks like

          1
                h,v
                 2
                 3
                 4
                  5
        for example.  Only the first point on the inflection is counted.
 -------------------------------------------------------------------------*/
static int start_inflection(h, v)
int     h, v;
{
        register int h_test, v_test, dir = 0, i;

        if (getpixel(h, v-1, &bmap))
                return false;                                   /* only count the start of an inflection */

        h_test = h - 1;         /* test the 1-3 */
        v_test = v - 1;
        for (i = 0; !getpixel(h_test, v_test, &bmap) && i < 3; i++, v_test++)
                ;

        if (i < 3)
                dir = 1;

        h_test = h + 1;         /* test the 4-6 */
        v_test = v - 1;
        for (i = 0; !getpixel(h_test, v_test, &bmap) && i < 3; i++, v_test++)
                ;

        if (i < 3)
                dir = -1;

        if (dir == 0)
                return false;                   /* no inflection here */

        /*
                final test: track pixels downward
                                        if the turn at the end is in the opposite direction
                                        as the original turn (indicated by dir)
                                        then it is an inflection
        */

        v_test = v;
        while (getpixel(h, v_test+1, &bmap))
                v_test++;

        if (v_test != v) {
                v = v_test;

                /* let's test the pixels again! */
                h_test = h - 1;         /* test the 1-3 */
                v_test = v - 1;
                for (i = 0; !getpixel(h_test, v_test, &bmap) && i < 3; i++, v_test++)
                        ;

                if (i < 3)
                        if (dir != 1)
                                return true;            /* no change in direction, inflection */
                        else
                                return false;           /* reversed direction, was a tangent */

                h_test = h + 1;         /* test the 4-6 */
                v_test = v - 1;
                for (i = 0; !getpixel(h_test, v_test, &bmap) && i < 3; i++, v_test++)
                        ;

                if (i < 3)
                        if (dir != -1)
                                return true;            /* no change in direction, inflection */
                        else
                                return false;
        }
        else
                return false;
}

#ifdef DEBUG

/*
        Here is some code to display the progress of the algorithm
        Fixed point math is used to speed up calculations.
        Fixed point math is tricky in a typed language like C or
        Pascal, and a cinch in assembly.
*/

#include <QuickDraw.h>

static Fixed int_to_fix(i)
int i;
```

```
{
          asm {
                    move.w    i,d0      ; get the number
                    ext.l     d0                  ; clear top of d0
                    swap      d0                  ; make it a fixed point number, all done
          }
}

static int fix_to_int(i)
Fixed i;
{
          asm {
                    move.l    i,d0                ; get the number
                    add.l     #0xA000,d0; add .5 to number, for rounding
                    swap      d0                            ; make the int, ignore upper word of d0
          }
}

static Fixed ratio = 0x00004000;

static show_point(h,v)
register int h, v;
{
          /*
                    draw each point in right window
                    scaled like the MacPaint draw function
          */
          GrafPtr oldPort;
          Rect r;

          GetPort(&oldPort);
          SetPort(right_wind);

          r.top    = fix_to_int(FixMul(int_to_fix(v), ratio));
          r.left   = fix_to_int(FixMul(int_to_fix(h), ratio));
          r.right  = r.left + 1;
          r.bottom = r.top + 1;

          FrameRect(&r);
          SetPort(oldPort);
}

static show_line(h1,v1,h2,v2)
register int h1, v1, h2, v2;
{
          /*
                    draw each line in right window
                    scaled like the MacPaint draw function
          */
          GrafPtr oldPort;

          GetPort(&oldPort);
          SetPort(right_wind);

          MoveTo(fix_to_int(FixMul(int_to_fix(h1), ratio)),
                    fix_to_int(FixMul(int_to_fix(v1), ratio)));
          LineTo(fix_to_int(FixMul(int_to_fix(h2), ratio)),
                    fix_to_int(FixMul(int_to_fix(v2), ratio)));

          SetPort(oldPort);
}
#endif
```

End Listing Nine

Listing Ten

```
/*
          getpixel.h

          contains function prototype for getpixel.c
*/

#include <QuickDraw.h>

extern int getpixel(int h, int v, BitMap *bmap);
```

End Listing Ten

Listing Eleven

```
/*------------------------------------------------------------------------
          getpixel.c
          Returns the value of pixel h, v in the bitmap "bmap".
          Written in 68000 inline assembly both because it is faster
          and because it is quite easy to do.  A version of this code
          was used by Mike Morton in his StarFlight program.

          This version has the following limitations:

          1.  It assumes that the cursor will not be in the way,
          i.e. it has either been hidden or we are looking at an off-screen
          bitmap.  In the contour map algorithm we are looking at an
          off-screen bitmap.

          2.  This version also assumes that the coordinates at the upper left
          are (0,0). Any offset tc the coordinate system (by a call to SetOrigin)
          is ignored.

          3.  This code will probably not work on the screen buffer for large screen
          Macs, color Macs, gray scale Macs, etc.  It works fine on off-screen bitmaps
          on my Mac II, as long as the depth is 1 bit per pixel.

          William May
          303A Ridgefield Circle
          Clinton, MA 01510

          Created:  1/20/87
          Modified: 3/21/87   Found a bug: getpixel wouldn't handle
                              bitmaps > 32K.
  ----------------------------------------------------------------------*/
```

(continued on next page)

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CIRCLE 294 ON READER SERVICE CARD

Listing Eleven *(Listing continued, text begins on page 18.)*

```
#include <QuickDraw.h>
#include <asm.h>

#include "getpixel.h"

int getpixel(h, v, bmap)
int h, v;
BitMap *bmap;
{
        asm {
                move.w    v,d0                                 ; load v and h into registers
                ext.l     d0
                move.w    h,d1
                ext.l     d1
                move.w    d1,d2                                ; copy h coord for bit offset
                                                               ; only need low order byte

                move.l    bmap,a0                              ; point to bitmap

                mulu      OFFSET(BitMap,rowBytes)(a0),d0
                                                               ; v * rowbytes is offset to row
                lsr.l     #3,d1                                ; extract byte offset
                add.l     d1,d0
                not.b     d2                                   ; make bit number 68000 style
                move.l    OFFSET(BitMap,baseAddr)(a0),a0
                                                               ; get base address of bitmap
                add.l     d0,a0                                ; get to the correct byte
                btst      d2,(a0)                              ; test the bit
                beq                @0

                moveq     #1,d0                                ; set value to 1
                return
@0
                moveq     #0,d0                                ; set value to 0
        }
}
```

End Listing Eleven

Listing Twelve

```
/*
        mem.h

        definition info for memory management

        William May

        created:  3/25/87
*/

#define SYSERR -1

/*
 * roundew, truncew - round up or truncate address to the next
 * even word.
 */

#define roundew(x)    (int *)((3 + (long)(x)) & (~3))
#define truncew(x)    (int *)(((long)(x)) & (~3))

#define DEFSIZE  (150000)       /* default size for a new pool */

/*
 * node structure for each node in the free memory list
 */
struct mblock {
        struct mblock *mnext;
        unsigned long mlen;
};

/*
 * structure for pools
 */
struct pool {
        struct pool *pnext;
        struct mblock firstblock;
};
```

End Listing Twelve

Listing Thirteen

```
/*-----------------------------------------------------------------
        getmem.c

        Implements low overhead memory management for nonrelocatable
        blocks on the Macintosh.  This code is based on "Operating System
        Design: The XINU Approach" by Douglas Comer (Prentice Hall, 1984.
        Great book!)

        Motivation:

        The Macintosh Memory Manager is designed to use relocatable
        blocks (i.e. pointers to pointers) for heap data structures.  In
        order that relocatable blocks be free to move the Memory Manager
        tries to keep nonrelocatable blocks (i.e. blocks referred to by
        pointers) out of the way, i.e. in low mem.  To do this, when a program
        asks for a nonrelocatable block the Memory Manager starts a linear
        search for available space at the bottom of the heap.  In an
        application such as a tree, where many thousands of small blocks are
        needed, the linear search technique quickly dies.

        The code below bypasses this problem by requesting one large block at
        the start of execution (i.e. when init_mem is called).  The function
        getmem then maintains a pointer to the next available block.  Thus
        any request for memory is satisfied immediately.  No search is needed.
        The performance difference in the contour analysis is quite dramatic.
```

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Listing Thirteen *(Listing continued, text begins on page 18.)*

```
          The code below is quite simple but not flexible.  One notable
          lack is for a routine to free memory.  Such a function is shown in
          Comer's book.  Another limitation that only one block is used.
          The functions can be extended to be able to add new blocks when it
          needs additional space.


          William May
          303A Ridgefield Circle
          Clinton, MA 01510

          created:  3/25/87     very primitive version, but works:
                                one pool only created
                                user has to guess the required space
                                speed increase is dramatic, especially
                                as the contour algorithm progresses (i.e.
                                as the AVL tree gets quite large).
  ------------------------------------------------------------------- */

#include <MemoryMgr.h>
#include "mem.h"

struct mblock memlist;                  /* head of free memory list */
struct pool *plist;                     /* head of pool list */

/*------------------------------------------------------------------
          init_mem creates a large memory pool, and initializes the necessary
          data_structures.
  -------------------------------------------------------------------*/
int init_mem()
{
          plist = (struct pool *)NewPtr(sizeof(struct pool) + DEFSIZE);

          if (MemErr == noErr) {
                    plist->pnext = (struct pool *)0;

                    memlist.mnext  = &(plist->firstblock);
                    (memlist.mnext)->mnext = (struct mblock *)0;
                    (memlist.mnext)->mlen  = (long)(DEFSIZE);
          }

          return MemErr;
}

/*------------------------------------------------------------------
          getmem allocates memory in the pool.  On successful completion
          a pointer to the allocated space is returned to the caller.  Otherwise
          a null pointer (0L) is returned.
  -------------------------------------------------------------------*/
int *getmem(nbytes)
unsigned long nbytes;
{
           register struct mblock *p, *q, *leftover;

           if (nbytes == 0) {
                     return (int *)0;
           }

           nbytes = (unsigned long)roundew(nbytes);

           for (q=&memlist, p=memlist.mnext; p != 0L; q=p, p=p->mnext)
                     if (p->mlen == nbytes) {
                               q->mnext = p->mnext;
                               return ((int *)p);
                     } else if (p->mlen > nbytes) {
                               leftover = (struct mblock *)((unsigned long)p + nbytes);
                               q->mnext = leftover;
                               leftover->mnext = p->mnext;
                               leftover->mlen = (long)(p->mlen - nbytes);
                               return ((int *)p);
                     }

            return ((int *)0);

}
```

End Listing Thirteen

Listing Fourteen

```
 /*------------------------------------------------------------
           error.c

           very primitive error handler

           William May
           303A Ridgefield Circle
           Clinton, MA 01510
   ------------------------------------------------------------*/

 #include <stdio.h>

 /*------------------------------------------------------------
           if an error number specified then print it,
           otherwise only print the message
   ------------------------------------------------------------*/
 syserr(errno, s)
 int errno;
 char *s;
 {
           if (errno) printf("Error (%d): %s\n", errno, s);
           else printf("Error: %s\n", s);

           ExitToShell();
 }
```

End Listings

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CIRCLE 95 ON READER SERVICE CARD

TURBO C TOOLBOX

Listing One *(Text begins on page 30.)*

```
/* VIDEO.I: Contains ROM BIOS video calls to be used in Turbo C */

#define  ROM  0x10

union REGS  inreg, outreg;

int videomode (int *ncols)                /* get current display mode */
{                                   /* return number of cols via *ncols */
  inreg.h.ah = 0x0F;
  int86 (ROM, &inreg, &outreg);
  *ncols = outreg.h.ah;                          /* number of cols */
  return (outreg.h.al);                             /* return mode */
} /* ------------------------- */
int activepage (void)                /* return active display page */
{
  inreg.h.ah = 0x0F;
  int86 (ROM, &inreg, &outreg);
  return (outreg.h.bh);
} /* ------------------------- */
void setmode (int mode)                          /* set video mode */
{
  inreg.h.al = mode;
  inreg.h.ah = 0x00;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------- */
void setcursor (int start, int end)            /* set cursor shape */
{
  inreg.h.ch = start;
  inreg.h.cl = end;
  inreg.h.ah = 0x01;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------- */
int curstart (void)                   /* get cursor starting line */
{
  inreg.h.bh = 0;              /* (cursor shape same in all pages */
  inreg.h.ah = 0x03;
  int86 (ROM, &inreg, &outreg);
  return (outreg.h.ch);
} /* ------------------------- */
int cursend (void)                      /* get cursor ending line */
{
  inreg.h.bh = 0;
  inreg.h.ah = 0x03;
  int86 (ROM, &inreg, &outreg);
  return (outreg.h.cl);
} /* ------------------------- */
void cursoff (void)                             /* turn cursor off */
{
  inreg.h.ch = curstart () | 0x10;               /* turn on bit 4 */
  inreg.h.cl = cursend ();
  inreg.h.ah =  0x01;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------- */
void curson (void)                               /* turn cursor on */
{
  inreg.h.ch = curstart () & 0x07;     /* turn off high order bits */
  inreg.h.cl = cursend ();
  inreg.h.ah =  0x01;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------- */
void gotoxy (int col, int row, int page)         /* set cursor pos */
{                                           /* must specify page */
  inreg.h.bh = page;
  inreg.h.dh = row;
  inreg.h.dl = col;
  inreg.h.ah = 0x02;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------- */
int wherex (int page)              /* return cursor column in page */
{
  inreg.h.bh = page;
  inreg.h.ah = 0x03;
  int86 (ROM, &inreg, &outreg);
  return (outreg.h.dl);
} /* ------------------------- */
int wherey (int page)                 /* return cursor row in page */
{
  inreg.h.bh = page;
  inreg.h.ah = 0x03;
  int86 (ROM, &inreg, &outreg);
  return (outreg.h.dh);
} /* ------------------------- */
void setpage (int page)               /* set active display page */
{
  inreg.h.al = page;
  inreg.h.ah = 0x05;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------- */
void cls (void)                             /* clear active screen */
{
  inreg.h.al = 25;                               /* entire screen */
  inreg.h.bh = 0x07;                       /* set to gray on black */
  inreg.h.ah = 0x06;
  inreg.h.cl =  0; inreg.h.ch =  0;
  inreg.h.dl = 79; inreg.h.dh = 24;
  int86 (ROM, &inreg, &outreg);
  gotoxy (0, 0, activepage ());
} /* ------------------------- */
void window (int  x1, int y1,          /* window upper left corner */
             int  x2, int y2,                /* lower right corner */
             char attrib)              /* text attribute inside */
{
  inreg.h.al = y2 - y1 + 1;               /* clear entire window */
  inreg.h.bh = attrib;
  inreg.h.cl = x1; inreg.h.ch = y1;
  inreg.h.dl = x2; inreg.h.dh = y2;
  inreg.h.ah = 0x06;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
void winScroll (int x1, int y1, int x2, int y2,   /* scroll window */
                int attr)                         /* one line upward */
{
  inreg.h.al = 1;
  inreg.h.cl = x1; inreg.h.ch = y1;
  inreg.h.dl = x2; inreg.h.dh = y2;
  inreg.h.bh = attr;
  inreg.h.ah = 0x06;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
char chattr (int foregrnd, int backgrnd)          /* character attrib*/
{
  return ((backgrnd << 4) + foregrnd);
} /* ------------------------ */
char rdchara (int page,                        /* read char at curs pos */
              char *attrib)              /* return attribute indirectly */
{
  inreg.h.bh = page;
  inreg.h.ah = 0x08;
  int86 (ROM, &inreg, &outreg);
  *attrib = outreg.h.ah;
  return (outreg.h.al);
} /* ------------------------ */
void wrtcha (char ch, char attrib,              /* write char + attrib */
             int page)                         /* at cursor pos on page */
{                                        /* NOTE: does not advance cursor */
  inreg.h.al = ch;
  inreg.h.bh = page;
  inreg.h.bl = attrib;
  inreg.x.cx = 1;
  inreg.h.ah = 0x09;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
void wrtstra (char *str,                                /* write string */
              char attrib,                          /* with attribute */
              int page)                                   /* to page */
{                                      /* starting at cursor position */
int   c, r, n, p = 0;

  videomode (&n);                             /* get width of screen */
  r = wherey (page);                              /* get current row */
  while (str[p]) {
    wrtcha (str[p++], attrib, page);              /* write next char */
    if ((c = wherex (page)) < (n - 1))
      gotoxy (c + 1, r, page);                     /* advance cursor */
    else
      gotoxy (0, ++r, page);                           /* else wrap */
  }
} /* ------------------------ */
void wrtch (char ch, int color,                 /* write char in color */
            int page)                   /* at cursor position on page */
{
  inreg.h.al = ch;
  inreg.h.bl = color;
  inreg.h.bh = page;
  inreg.x.cx = 1;
  inreg.h.ah = 0x0A;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
void wrtstr  (char *str,                                /* write string */
              char color,                                   /* in color */
              int page)                                    /* to page */
{                                      /* starting at cursor position */
int   c, r, n, p = 0;

  videomode (&n);                             /* get width of screen */
  r = wherey (page);                              /* get current row */
  while (str[p]) {
    wrtcha (str[p++], color, page);               /* write next char */
    if ((c = wherex (page)) < (n - 1))
      gotoxy (c + 1, r, page);                     /* advance cursor */
    else
      gotoxy (0, ++r, page);                           /* else wrap */
  }
} /* ------------------------ */
void palette (int palno)                          /* set color palette */
{                                      /* valid only in mode 4 on CGA */
  inreg.h.bh = 1;
  inreg.h.bl = palno;
  inreg.h.ah = 0x0B;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
void graphbackground (int color)           /* set graphics b/g color */
{
  inreg.h.bh = 0;
  inreg.h.bl = color;
  inreg.h.ah = 0x0B;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
void plot (int x, int y, int pixel)              /* plot pixel at x, y */
{                                               /* pixel (color) value */
  inreg.h.al = pixel;
  inreg.h.bh = 0;
  inreg.x.cx = x;
  inreg.x.dx = y;
  inreg.h.ah = 0x0C;
  int86 (ROM, &inreg, &outreg);
} /* ------------------------ */
int pixel (int x, int y)                 /* return pixel value at x, y */
{
  inreg.x.cx = x;
  inreg.x.dx = y;
  inreg.h.ah = 0x0D;
  int86 (ROM, &inreg, &outreg);
  return (outreg.h.al);
} /* ------------------------ */
```

End Listing One

(Listing Two begins on next page)

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Listing Two *(Text begins on page 30.)*

```
/* VIDEO.H: Prototypes for contents of user-written VIDEO.LIB */
/* Describes calls to ROM BIOS video functions */

int videomode (int *ncols);
int activepage (void);
void setmode (int mode);
void setcursor (int start, int end);
int curstart (void);
int cursend (void);
void cursoff (void);
void curson (void);
void gotoxy (int col, int row, int page);
int wherex (int page);
int wherey (int page);
void setpage (int page);
void cls (void);
void window (int x1, int y1, int x2, int y2, char attrib);
char chattr (int fgrnd, int bgrnd);
char rdchara (int page, char *attr);
void wrtcha (char ch, char attr, int page);
void wrtstra (char *str, char attr, int page);
void wrtch (char ch, int color, int page);
void wrtstr (char *str, char color, int page);
void palette (int palno);
void graphbackground (int color);
void plot (int x, int y, int pixel);
int pixel (int x, int y);
```

End Listing Two

Listing Three

```
/* DRAW.I: Draws lines in graphics mode */

/* hdraw draws horizontal line along y between x1 and x2 */
void hdraw (int x1, int x2, int y, int color)
{
int    x;

  if (x1 > x2) {                /* sort x's into left-to-right order */
    x = x1; x1 = x2; x2 = x;
  }
  for (x = x1; x <= x2; x++)
    plot (x, y, color);
} /* ------------------------ */

/* vdraw draws vertical line along x between y1 and y2 */
void vdraw (int y1, int y2, int x, int color)
{
int    y;

  if (y1 > y2) {                 /* sort y's into top-to-bottom order */
    y = y1; y1 = y2; y2 = y;
  }
  for (y = y1; y <= y2; y++)
    plot (x, y, color);
} /* ------------------------ */

/* draw() does lines on the diagonal */
void draw (int x1, int y1, int x2, int y2, int color)
{
double   xstep, ystep, xcum = 0.0, ycum = 0.0;
int      dx, dy;                                        /* deltas */
register x, y;

  dx = x2 - x1;
  dy = y2 - y1;
  if (abs (dx) >= abs (dy)) {                   /* plot along x axis */
    ystep = (double) dy / dx;        /* movement along y axis per x */
    if (dy < 0) {                           /* y travels to the left */
      if (ystep > 0)
        ystep *= -1;              /* adjust for wrong sign from -y/-x */
    } else                                 /* y travels to the right */
      if (ystep < 0)
        ystep *= -1;                             /* adjust as above */
    dx /= abs (dx);                                  /* x increment */
    for (x = x1, y = y1; x != x2; x += dx) {
      plot (x, y, color);
      ycum += ystep;                       /* cum motion along y axis */
      y = y1 + ycum;                                      /* next y */
    }
  } else {                                      /* plot along y axis */
    xstep = (double) dx / dy;        /* movement along x axis per y */
    if (dx < 0) {
      if (xstep > 0)
        xstep *= -1;
    } else
      if (xstep < 0)
        xstep *= -1;
    dy /= abs (dy);                                  /* y increment */
    for (y = y1, x = x1; y != y2; y += dy) {
      plot (x, y, color);
      xcum += xstep;                       /* cum motion along x axis */
      x = x1 + xcum;                                      /* next x */
    }
  }
} /* -------------------------- */
```

End Listing Three

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Listing Four

```
/* COLORS.H: Maps color names */

#define BLACK          0
#define BLUE           1
#define GREEN          2
#define CYAN           3
#define RED            4
#define MAGENTA        5
#define BROWN          6
#define LIGHTGRAY      7
#define DARKGRAY       8
#define LIGHTBLUE      9
#define LIGHTGREEN     10
#define LIGHTCYAN      11
#define LIGHTRED       12
#define LIGHTMAGENTA 13
#define YELLOW         14
#define WHITE          15
```

End Listing Four

Listing Five

```
/* VID.C: Demos video functions */

/* TURBO C INCLUDES */
#include <stdio.h>
#include <bios.h>
#include <dos.h>

/* USER-WRITTEN INCLUDES */
#include <colors.h>
#include <video.i>
#include <draw.i>

/* LOCAL FUNCTION PROTOTYPES */
int  vidIdent (int *vidmode);
void wait (void);
void stairsteps (void);
int  isEGA (void);
void label (void);
void bigX (int adap, int vmode);
void hourglass (int adap, int vmode);

/* GLOBALS */
enum vidTypes {mda, cga, ega, compaq, other};
```

```
main ()
{
int  adaptor, mode, cols;

  cls ();                                                /* clear screen */
  adaptor = vidIdent (&mode);                   /* identify video adaptor */
  if (adaptor != other) {
    stairsteps ();                             /* cursor positioning demo */
    bigX (adaptor, mode);                             /* graphics demo #1 */
    hourglass (adaptor, mode);                        /* graphics demo #2 */
    label ();
    gotoxy (36, 12, 0);
    puts ("All done!");
  }
} /* ------------------------ */
int  vidIdent (int *vidmode)                    /* identify video adaptor */
{
int  flag, adap, width;

  label ();                                             /* label display */
  puts ("\n\nDISPLAY INFORMATION:");
  *vidmode = videomode (&width);                       /* get video mode */
  flag = (biosequip () & 0x18) >> 4;             /* get video eqpt flag */
  if (isEGA ()) {
    adap = ega;
    puts ("\n\n  Enhanced Graphics Adaptor");
  } else
    switch (flag) {
      case 0: if (*vidmode == 2) {
                adap = compaq;
                puts ("\n\n  Compaq adaptor");
              } else {
                adap = cga;
                puts ("\n\n  Color Graphics Adaptor");
              }
              break;
      case 3: adap = mda;
              puts ("\n\n  Monochrome Display Adaptor");
              break;
      default: adap = other;
              puts ("\n\n  Adaptor not usable in this demo. Sorry.");
    } /* end of switch */
  printf ("\n  Text screen size is %d columns x 25 rows\n", width);
  if ((*vidmode < 4) || (*vidmode == 7))
    puts ("\n  Text mode currently active");
  else
    puts ("\n  Graphics mode currently active");
  wait ();
  return (adap);
```

(continued on next page)

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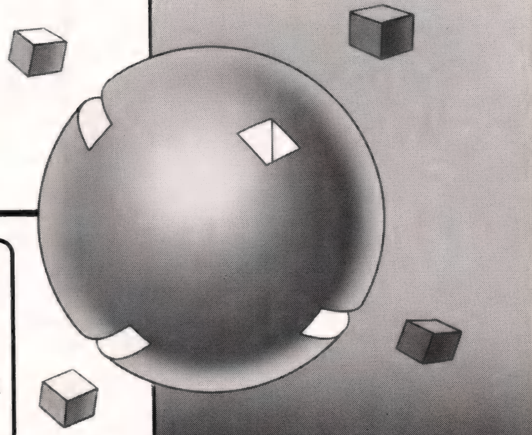

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Listing Five

(Listing continued, text begins on page 30.)

```
} /* ------------------------- */
int  isEGA (void)                  /* determine if EGA is attached */
{                                /* return TRUE if so, FALSE if not */
  return (peekb (0x40, 0x87));              /* check EGA info byte */
} /* ------------------------- */

void wait (void)           /* prompt to continue, wait for keypress */
{
int   tab, width;

  videomode (&width);                       /* get width in columns */
  tab = (width - 33) / 2;              /* starting column for text */
  gotoxy (tab, 24, 0);
  wrtstr ("Press any key to continue demo...", WHITE, 0);
  getch ();
  cls ();
} /* ------------------------- */
void label (void)                   /* label the screen at top center */
{
  gotoxy (30, 0, 0);
  wrtstra ("Video demonstration", chattr (YELLOW, BLUE), 0);
} /* ------------------------- */
void stairsteps (void)
{
int   color = 1;

   label ();
   gotoxy (31,  2, 0); wrtstr ("Cursor positioning", LIGHTGRAY, 0);
   gotoxy (10,  4, 0); wrtstr ("Stair", color++, 0);
   gotoxy (20, 10, 0); wrtstr ("steps", color++, 0);
   gotoxy (30, 16, 0); wrtstr ("going", color++, 0);
   gotoxy (40, 22, 0); wrtstr ("down",  color++, 0);
   gotoxy (50, 16, 0); wrtstr ("and",   color++, 0);
   gotoxy (60, 10, 0); wrtstr ("back",  color++, 0);
   gotoxy (70,  4, 0); wrtstr ("up",    color, 0);
   wait ();
} /* ------------------------- */
void bigX (int vidAdap, int vmode)           /* APA graphics demo #1 */
{                    /* draws full-screen border and X, adjusting */
                                          /* for EGA or CGA as indicated */
int  x1 =  0, x2 = 639;
int  y1 = 15, y2;

  if ((vidAdap == mda) || (vidAdap == other))        /* can't do it */
    return;                              /* so return with no action */

  if (vidAdap == ega) {             /* EGA demo: 640 x 350 (mode 0Fh) */
    y2 = 349 - 15;                   /* set bottom of graphics screen */
    setmode (0x0F);                 /* go to EGA mono graphics mode */
  } else {                /* CGA|Compaq demo: 640 x 200 (mode 06h) */
    y2 = 199 - 15;
    setmode (0x06);
  }
  label ();                                     /* label the screen */
  hdraw (x1, x2, y1, 1);                     /* draw line across top */
  hdraw (x1, x2, y2, 1);                              /* then bottom */
  vdraw (y1, y2, x1, 1);                           /* down left side */
  vdraw (y1, y2, x2, 1);                          /* down right side */
  draw (x1, y1, x2, y2, 1);                          /* main diagonal */
  draw (x1, y2, x2, y1, 1);                         /* cross diagonal */
  wait ();
  setmode (vmode);
} /* ------------------------- */
void hourglass (int vidAdap, int vmode)          /* graphics demo #2 */
{                   /* operates in 320 x 200 four-color (CGA) mode */
int      y, x1 = 60, x2 = 260, pixval = 1;

  if ((vidAdap == mda) || (vidAdap == other))         /* can't do it */
    return;                                            /* so go back */
  setmode (4);                           /* go to CGA graphics mode */
  gotoxy (8, 0, 0);
  puts ("320 x 200 color graphics");                    /* show mode */
  palette (0);
  for (y = 50; y < 151; y++ ) {                      /* draw figure */
    hdraw (x1, x2, y, pixval);
    x1 += 2; x2 -= 2;                                  /* change x's */
    if (y ==  84) pixval = 2;                      /* change colors */
    if (y == 117) pixval = 3;
  }
  wait ();
  setmode (vmode);
} /* ------------------------- */
```

End Listings

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Listing One *(Text begins on page 46.)*

```
Screen # 0

\                                                    jbb 15:47 08/04/87

                              GETIMAGE


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                                  by
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                           August 4, 1987

            Loads an EGAPAINT file into video memory
       from within UR/FORTH for subsequent animation, etc.



Screen # 1

\ Misc.                                              jbb 13:01 08/04/87
DOSINT                                   \ fetch level 2 DOS interface
HCB IMAGEHCB                             \ create the handle block
CREATE PALTAB  16 ALLOT                  \ to hold egapaint's palette

: ?MEMREQ ( x1 y1 x2 y2 - bytes)  \ calc. memory req to @BLOCK
   ROT - 1+  -ROT SWAP - 1+ 2/ 1+  *  4 + ;

HEX
: RESTORE-EGA ( - )            \ restore EGA's default mode:
   2 3C4 PC!  0F 3C5 PC!       \ default map mask
   3 3CE PC!   0 3CF PC!       \ default data rotate reg value
   5 3CE PC!   0 3CF PC!       \ default write mode 0
   8 3CE PC!  FF 3CF PC! ;     \ default bit mask
DECIMAL
-->


Screen # 2

\ EGA map mask control                               jbb 15:37 08/04/87

HEX

: READMODE0 ( - )   5 3CE PC!  8 3CF PC! 2 3CE PC! 0 3CF PC! ;

          \ set map-masks to select active EGA color bit-planes
: BLUEPLANE     ( - ) 2 3C4 PC!  1 3C5 PC! ; \ plane 0
: GREENPLANE    ( - ) 2 3C4 PC!  2 3C5 PC! ; \ plane 1
: REDPLANE      ( - ) 2 3C4 PC!  4 3C5 PC! ; \ plane 2
: INTENSEPLANE ( - ) 2 3C4 PC!  8 3C5 PC! ; \ plane 3

DECIMAL
-->



Screen # 3

\ File control                                       jbb 12:59 08/04/87

: OPENIMAGEFILE ( ^filename - )
   IMAGEHCB NAME>HCB                          \ force filename
   IMAGEHCB O_RD FOPEN                        \ open file for reading
   IF ABORT" Can't open file." THEN ;

: CLOSEIMAGEFILE ( - )  IMAGEHCB FCLOSE DROP ;

: MAKEIMAGEFILE ( ^filename - )
   IMAGEHCB NAME>HCB                          \ force filename
   IMAGEHCB 0 FMAKE                           \ make "normal" file
   IF ABORT" Can't make file." THEN ;
-->



Screen # 4

\ Read EGAPAINT file from disk to video      jbb 15:45 08/04/87

\ To load EGAPAINT disk image into EGA video segment...
\ set map mask, read bytes from disk, repeat for each plane

: READBYTES ( - )      \ read  28,000 bytes to video segment
   IMAGEHCB  ?VSEG 0  \ source-handle; dest.- videoseg:offset
   28000 FREADL        \ read 28,000 bytes
   DROP ;              \ drop flag.

: READPAINTFILE ( - ) \ read all four planes in sequence...
     BLUEPLANE  READBYTES  REDPLANE READBYTES
     GREENPLANE READBYTES  INTENSEPLANE READBYTES ;
-->



Screen # 5

\
                                                     jbb 15:44 08/04/87
: LOADPAINTFILE ( ^filename - )
   640X350 VMODE  CLS                 \ hi-res 16-color
   OPENIMAGEFILE                         \ Open the file, and
   IMAGEHCB PALTAB 16 FREAD              \ read palette data.
     IF PALTAB !PALETTE                  \ If read was successful,
      THEN                               \ set palette to new colors.
   READMODE0                             \ Set read mode 0 and
   READPAINTFILE                         \ read the bit-plane data.
   CLOSEIMAGEFILE                        \ Close the file, and
   RESTORE-EGA ;                         \ restore the EGA defaults.
-->



Screen # 6

\ Load the EGAPAINT full-screen image          jbb 15:17 08/04/87

CREATE BARON  ,C" THEFOKKR.IMG"  \ orig 112K EGAPAINT disk file
CREATE FOKKER ,C" DERFOKKR.IMG"  \ new smaller @BLOCK disk file
CREATE DR.1   3072 ALLOT         \ memory req as multiple of 8

: SAVEDR.1    1 1 106 53  DR.1 @BLOCK ;    \ get block to memory

: GETIMAGE BARON LOADPAINTFILE SAVEDR.1 ; \ get orig image>mem

: SAVEFOKKER   FOKKER MAKEIMAGEFILE  \ build .img file on disk
   IMAGEHCB PALTAB 16 FWRITE DROP    \ include pallete info
   IMAGEHCB DR.1 2904 FWRITE DROP    \ write DR.1 mem to disk
   CLOSEIMAGEFILE ;                  \ close it out...
-->


Screen # 7

\ CHECKOUT  JUNK                                jbb 16:07 08/04/87

: CK1  HR DR.1 267 148 !BLOCK
       277 156 361 192 FRAME           \ Fokker image limits
       LTBLUE FG
       267 148 372 200 FRAME           \ image area saved
       262 143 272 153 FRAME           \ hit zone around CORNER
       314 165 324 175 FRAME ;         \ hit zone on Fokker

: GUNSIGHT ( - )   ORANGE FG  269 170 369 170 LINE
   319 133 319 274 LINE  319 170 50 circle ;

: CK  CK1  GUNSIGHT ;
```

End Listing One

Listing Two

```
Listing 2.  Pseudocode to move a full 112,000 byte image
from the disk to the screen:  NOTE:  ALL NUMBERS HEXIDECIMAL

Set the video mode to graphics mode xx however your language
does it.

Open the file using a DOS handle however your language does
it.

If palette data is the first data in the file,
Then read the palette data and set the new palette.  (This
should be covered in your language's high level routines.)

Set read mode 0
Write  5 to port 3CE, then
write  8 to port 3CF, then
write  2 to port 3CE, then
write  0 to port 3CF.

Set map mask to plane 0 (blue plane)
Write  2 to port 3C4, then
write  1 to port 3C5.

Read 28,000 bytes from the file to A000:0000 however your
language does it.

Set map mask to plane 2 (red plane)
Write 2 to port 3C4, then
write 4 to port 3C5.

Read 28,000 bytes from the file to A000:0000 however your
language does it.

Set map mask to plane 1 (green plane)
Write 2 to port 3C4, then
write 4 to port 3C5.

Read 28,000 bytes from the file to A000:0000 however your
language does it.

Set map mask to plane 3 (intensity plane)
Write  2 to port 3C4, then
write  8 to port 3C5.

Read 28,000 bytes from the file to A000:0000 however your
language does it.

Close the file, however your language does it.

Restore EGA default values.
(set map mask default: all planes active)
Write  2 to port 3C4, then
write 0F to port 3C5.
```

```
(set data rotate register default)
Write  3 to port 3CE, then
write  0 to port 3CF.

(set default write mode 0)
Write  5 to port 3CE, then
write  0 to port 3CF.

(set default bit-mask)
Write  8 to port 3CE, then
write FF to port 3CF.
```

End Listing Two

Listing Three

```
Screen # 0

\                                                 jbb 17:28 07/04/87

                          FOKKER.SCR
                A Mindless Game of Motor Skill
                (somewhere over the trenches...)

NOTE: YOU ABSOLUTELY MUST HAVE CRUISE CONTROL, OR SOME OTHER
      KIND OF KEYBOARD SPEEDUP SOFTWARE FOR THIS TO WORK !!!

                       Standard Version
             Copyright (C) 1987, All Rights Reserved

                              by
                       J. Brooks Breeden

              EGAGRAPH.EXE must be loaded first


Screen # 1

\ File control...                                 jbb 13:08 08/04/87
\ this screen is required to load image initially.
\ For turnkey, the image is in memory & this scr isn't required

 DOSINT                              \ level 2 DOS interface

HCB IMAGEHCB                        \ create the handle block

: OPENIMAGEFILE ( ^filename - )
   IMAGEHCB NAME>HCB                \ force filename
   IMAGEHCB O_RD FOPEN              \ open file for reading
   IF ABORT" Can't open file." THEN ;

: CLOSEIMAGEFILE  ( -- )
   IMAGEHCB FCLOSE DROP ;           \ close, ignore status
-->


Screen # 2

\ File control...                                 jbb 09:49 08/01/87

CREATE DR.1   3000 ALLOT              \ to hold the bit map image
CREATE PALTAB   16 ALLOT              \ new palette of colors
CREATE FOKKERIMG ," DERFOKKR.IMG"     \ name of the image file

: GETFOKKER             \ load binary image from disk to memory
   DR.1 3000 ERASE                    \ clean out memory area
   FOKKERIMG OPENIMAGEFILE            \ open 'er up
   IMAGEHCB PALTAB 16 FREAD DROP      \ read in palette info
   IMAGEHCB DR.1 2866 FREAD  DROP     \ read in the image
   CLOSEIMAGEFILE ;                   \ close the file

GETFOKKER        \ load the Fokker image during the compile...
-->              \ Note: Obviously, you'd better have the image
                 \ file in your directory at this point!


Screen # 3

\ Pallette colors                                 jbb 17:10 08/02/87

: FG   FOREGROUND ;                  \  shorthand for LMI's words
: BG   BACKGROUND ;
: HR   640X350 VMODE ;               \ high res EGA 16-color mode

\ Named colors for the EGAPAINT default pallette
0 CONSTANT BLACK       8 CONSTANT GREEN
1 CONSTANT DKGRAY      9 CONSTANT LTGREEN
2 CONSTANT GRAY       10 CONSTANT CYAN
3 CONSTANT DKRED      11 CONSTANT LTBLUE
4 CONSTANT RED        12 CONSTANT BLUE
5 CONSTANT ORANGE     13 CONSTANT DKBLUE
6 CONSTANT YELLOW     14 CONSTANT PURPLE
7 CONSTANT DKGREEN    15 CONSTANT WHITE
-->


Screen # 4

\ Utilities                                       jbb 09:53 08/01/87

 : TAB ( row col - )  SWAP  GOTOXY ;            \ clearer for text
 : ?   @ . ;
                  \ returns unique IBM keycode for each keypress
 : MYKEY ( - n)   KEY DUP 0= IF DROP KEY 128 + THEN ;

 : WAIT ( - )   MYKEY  DROP ;                  \ wait for a keypress
 \ vector math...
 : V+ ( a b c d --- a+c b+d)   >R ROT + SWAP R> + ;
 : V* ( a b c d --- a*c b*d)   >R ROT * SWAP R> * ; \ not used;
 : V/ ( a b c d --- a/c b/d)   >R ROT / SWAP R> / ; \ for info..
: S-LINE ( row - )   0 TAB  80 0 DO 196 EMIT LOOP ; \ a line
: D-LINE ( row - )   0 TAB  80 0 DO 205 EMIT LOOP ; \ dbl. line
-->

Screen # 5

\ Random number generator                         jbb 09:56 08/01/87

VARIABLE SEED
@TIME COMBINE SEED !                    \ plant seed w/system clock

: random ( - n )                               \ 0 <= n <= 32767
   SEED @ 259 * 3 + 32767 AND  DUP SEED ! ;

: RANDOM ( n1 - n2 )                                \ 0 <= n2 < n1
   random M* 32768 UM/MOD NIP ;

: BETWEEN  ( lo# hi# - inbetween#)   OVER - RANDOM + ;

: WITHIN? ( n hi# lo# - flag)   >R 1- OVER < SWAP R> < AND ;
-->


Screen # 6

\ Fokker movement                                 jbb 14:44 08/06/87

2VARIABLE CORNER    \ xy-coords of up-left corner of fokker box

-1 1 2EQU RANGE                 \ range of random fokker movement

          \ add to Baron's excitement by bumping allowed RANGE
: EXCITEMENT ( - )   RANGE -1 1 V+ 2EQU RANGE ;

   \ leaves random x and y within RANGE by which to move Fokker
: MOVEFOKKER ( - n n)   RANGE BETWEEN RANGE BETWEEN ;

: GUNSIGHT ( - )   ORANGE FG  269 170 369 170 LINE
   319 133 319 274 LINE  319 170 50 circle ;
-->


Screen # 7

\ Stick control                                   jbb 10:05 08/01/87

                  \ set gunsight movement based on #key pressed
: ?stick ( adr - adr n n)  MYKEY
      CASE 199 OF  2 -2 ENDOF    200 OF  0 -2 ENDOF
           201 OF -2 -2 ENDOF    205 OF -2  0 ENDOF
           209 OF -2  2 ENDOF    208 OF  0  2 ENDOF
           207 OF  2  2 ENDOF    203 OF  2  0 ENDOF
     ( otherwise)  0  0              \ leave 0's for V+ to add...
           ROT                       \ move index to top of stack
     ENDCASE  ;                      \ for ENDCASE to drop...

: ?STICK ( adr - adr n n) ?TERMINAL   \ key pressed?
   IF  ?stick                         \ check stick control
   ELSE  0 0  THEN ;                  \ leave zeros for "V+"
-->

Screen # 8

\ Exclamations!                                   jbb 10:12 08/01/87

\ These aren't real serious curses; you make up your own!
CREATE CURSES ," Dankeschoen!        Welkommen!          Wie Geh
ts?          Was ist das?        Weiner Schnitzel!   Bratwurst!
       Sauerbrauten!        Knockwurst!          Sauerkraut!
    Weisswurst           "

: EXCLAMATION      \ shout a curse at the user, for distraction
   3 30 TAB CLREOL  3 33 TAB ORANGE FG
   10 RANDOM 20 * CURSES + 20  -TRAILING TYPE ;
-->


Screen # 9

\  Damage report                                  jbb 10:14 08/01/87

VARIABLE #HITS                           \ # of hits in cockpit zone
VARIABLE AMMO                            \ rounds of ammunition left

: .HITS   GRAY FG 22 44 TAB #HITS ? ;     \ print out number of
: .AMMO   GRAY FG 23 44 TAB AMMO  ? ;      \ hits & ammo left.

: HIT?   CORNER 2@ 143 153 WITHIN? \ y in hit zone?
   SWAP 262 272 WITHIN?  AND       \ x in hit zone?  Both?

    IF 2 #HITS +! .HITS               \ Increment hits & show #.
      #HITS @ 4 MOD 0=                \ For every 4 hits, increase
      IF EXCITEMENT  EXCLAMATION      \ movement & display curse!
      THEN
    THEN ;
 -->


 Screen # 10

 \  Shooting...                                   jbb 10:19 08/01/87

 : 2SHOTS   219 349 319 170 LINE 419 349 320 170 LINE ;

 : FIREGUNS     \ fire two shots, decrement ammo, show ammo left
    WHITE FG  2SHOTS
    5000 0 DO  LOOP   \ kill some time
    DKBLUE FG  2SHOTS  -2 AMMO +! .AMMO ;
```

(continued on next page)

Listing Three *(Listing continued, text begins on page 46.)*

```
: SHOOTING?   ?TERMINAL           \ If there is keyboard input...
   IF MYKEY 32 =                  \ was it the spacebar?
     IF AMMO @                    \ Yes, if we have any ammo,
       IF FIREGUNS HIT? THEN      \ shoot & check if we hit the
     THEN                         \ Fokker.
   THEN ;
-->


Screen # 11

\ Explosion                                     jbb 15:01 08/04/87

: BURST   320 0   \ random dots expanding in all four quadrants
   DO 319 I RANDOM + 174 I RANDOM - !PEL
      319 I RANDOM + 174 I RANDOM + !PEL
      319 I RANDOM - 174 I RANDOM + !PEL
      319 I RANDOM - 174 I RANDOM - !PEL LOOP  ;

: EXPLODE   3 0 DO  BURST  LOOP ;   \ it pulses the bursts...

HEX                     \ clear bios buffer of waiting keypresses
: CLR-KEY-BUF    0C01 regAX ! 21 INT86 ;
DECIMAL

: WAIT-FOR-ESC   CLR-KEY-BUF  BEGIN  MYKEY 27 =  UNTIL ;
-->


Screen # 12

\ Win message                                   jbb 17:35 07/04/87

: WIN                      \ what happens if you shoot him down!
   WHITE FG EXPLODE  DKBLUE FG REVERSE  ORANGE FG 6 14 TAB
   ."  What a pilot!  You downed the baron with "
   100 AMMO @ - .  ." rounds. "
   7 14 TAB
   ."  Now it's time to head for home and celebrate.       "
   20 25 TAB
   ."  Press ESC to go home in GLORY. " GRAY FG REVERSE
   WAIT-FOR-ESC ;
-->


Screen # 13

\ Lose message                                  jbb 10:20 08/01/87

: LOSE             \ what happens if you DON'T shoot him down...
   DKBLUE FG REVERSE  ORANGE FG 6 14 TAB
   ."  You are a rotten pilot!  You waste ammunition, and "
   7 14 TAB
   ."  let yourself get outflown by the bloody Red Baron. "
   8 14 TAB
   ."  Tuck your tail beween your legs and head for home. "
   20 23 TAB
   ."  Now press ESC to go home in SHAME! "
   DKBLUE FG REVERSE  GRAY FG  WAIT-FOR-ESC ;
-->


Screen # 14

\ Setup                                         jbb 10:22 08/01/87

F: FOKKER                                 \ forward reference

: SETUP   HR PALTAB !PALETTE CLS          \ use EGAPaint palette
    DKBLUE BG  GUNSIGHT                   \ paint sky and gunsight
   -1 1 2EQU RANGE                        \ fokker motion range
   175 375 BETWEEN  104 254 BETWEEN       \ random starting points
   CORNER 2!  0 #HITS !  100 AMMO !       \ setup the variables
   GRAY FG
   22 34 TAB ." # OF HITS: " .HITS         \ show hits
   23 34 TAB ." AMMO LEFT: " .AMMO ;       \ show ammo
-->

Screen # 15

\ Major loop                                    jbb 10:23 08/01/87

: DOGFIGHT   SETUP                      \ get ready...
   BEGIN  DR.1                          \ address of fokker bitmap
     CORNER 2@ MOVEFOKKER V+            \ +random movement
     ?STICK V+       ( --- adr x y)     \ +stick control
     2DUP CORNER 2! !BLOCK              \ update corner; show plane
     SHOOTING?  #HITS @ 19 >            \ check hits in pilot zone
       IF WIN  EXIT THEN                \ blow up plane; you win.
     AMMO @ 0=                          \ out of ammo?
       IF LOSE EXIT THEN                \ you lose...
     GUNSIGHT                           \ redisplay gunsight
   AGAIN  ;
-->

Screen # 16

\ Options
                                                jbb 10:23 08/01/87
: D-LINES
   B/W CLS PURPLE FG 7 D-LINE 19 D-LINE RED FG ; \ double lines

: .OPTIONS    D-LINES
    6  0 TAB ." Fokker" 6 36 TAB ." OPTIONS"    LTBLUE FG
   11 31 TAB ." F1.  " GRAY FG ." Instructions" LTBLUE FG
   13 31 TAB ." F2.  " GRAY FG ." Play"         LTBLUE FG
   15 31 TAB ." F10. " GRAY FG ." Exit"
   20 0 TAB ;
-->



Screen # 17

\ Credits                                       jbb 13:25 07/31/87

: .CREDITS    D-LINES  6 36 TAB ." FOKKER"  LTBLUE FG 8 23 TAB
   ." (A Mindless Game of Motor Skill)"  11 20 TAB  RED FG
   ." Somewhere over the trenches in France..."
   GRAY FG 14 22 TAB
   ." Copyright 1987, All Rights Reserved" 15 38 TAB ." by "
   16 32 TAB ." J. Brooks Breeden" 17 32 TAB ." Columbus, Ohio"
    ORANGE FG  20 26 TAB ." Press Any Key to Continue..."
   23 11 TAB LTBLUE FG
   ." Written in UR/FORTH from Laboratory Microsystems, Inc."
   24  9 TAB
 ." Fokker Dr.1 created with EGAPAINT from RIX Softworks, Inc."
  ;
-->


Screen # 18

\ Help...                                       jbb 13:24 07/31/87

: HELP1   B/W CLS RED FG  1 20 TAB ." Your Mission:"
   PURPLE FG 2 S-LINE  LTBLUE FG  3 20 TAB
   ." Your mission is to down the Red Baron with 20 hits"
   4 20 TAB
   ." in the cockpit area of his Fokker Dr.1 triplane."
   5 20 TAB
   ." When you shoot, the Baron gets excited, and takes"
   6 20 TAB
   ." evasive action.  You have 100 rounds of ammo left,"
   7 20 TAB
   ." and your guns have a tendency to jam..." ;
-->


Screen # 19

\ Help...                                       jbb 13:21 07/31/87

: HELP2   RED FG  9 20 TAB
   ." To play..."  PURPLE FG 10 S-LINE LTBLUE FG  11 20 TAB
   ." The cursor keys control the gunsight like a joystick."
   12 20 TAB
   ." The up arrow key pushes the stick forward.  The down"
   13 20 TAB
   ." arrow key pulls back on the stick.  Left, right, and"
   14 20 TAB
   ." diagonal keys move the stick as you would expect."
   16 20 TAB
   ." Fire by holding down the space bar."
   21 20 TAB
   ." Press Ctrl-Break to quit at any time." ;
-->

Screen # 20

\ Warning...                                    jbb 10:24 08/01/87

: WARNING    D-LINES  6 34 TAB ." WARNING!!!" LTBLUE FG
    9 20 TAB ." YOU ABSOLUTELY MUST HAVE CRUISE CONTROL,"
   10 20 TAB ." QUICKEYS, OR OTHER TSR KEYBOARD SPEED-UP"
   11 20 TAB ." RESIDENT IN ORDER TO RUN THIS PROGRAM !!!"
   13 20 TAB ." If you do not have a keyboard speed-up"
   14 20 TAB ." program resident, press Ctrl-Break to exit."
   16 20 TAB ." If a keyboard speed-up program is resident..."
   ORANGE FG  20 26 TAB ." Press Any Key to Continue..."
   WAIT ;

: .HELP   HELP1 HELP2  ORANGE FG  23 26 TAB
   ." Press Any Key to Continue..."  WAIT FOKKER ;
-->


Screen # 21

\ Main resolved                                 jbb 10:24 08/01/87

: INTRO   CLS B/W  .CREDITS WAIT  20 0 TAB CLREOL ;

R: FOKKER .OPTIONS MYKEY       \ resolve FOKKER forward reference
   CASE  187 OF .HELP FOKKER ENDOF          \ show instructions
         188 OF  DOGFIGHT  FOKKER ENDOF     \ do the dogfight
         196 OF  BYE  ENDOF                 \ exit to DOS
         DROP FOKKER                        \ recurse to options
   ENDCASE ;


: MAIN   HR PALTAB !PALETTE WARNING INTRO FOKKER ;
```

End Listings

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CIRCLE 391 ON READER SERVICE CARD

Listing One

(Text begins on page 38.)

```
    @Listing 1@.  The @SaveRegion@ Procedure copies any
    upright rectangular graphics screen region into
    a buffer, @buff@, where its upper-left (x1,y1)
    and lower-right (x2,y2) screen coordinates are
    specified.  GETMEM is used to allocate memory,
    rather than the standard NEW, because the buffer
    size needs to be computed at run time.


{The following code is the property of H.D.
Callihan, University of Pittsburgh at Johnstown,
Johnstown, Pa.  Personal use is encouraged.  Feel
free to make copies for distribution to other
personal users.  Commercial use is prohibited
without written permission and an
appropriate license.

Version:  4      (requires the CRTmode function in
                 file:  CRTMODE.INC) Purpose:
                 save and restore a current screen
                 region in low- or hi-res mode.
   Date:  6/22/87
 Author:  H.D. Callihan, Ph.D.  (C) Copyright 1987
 Applic:  Turbo V3.0 for IBM PC and true compatibles.
   File:  GREGION4.INC
}


TYPE
    buffermemory = ARRAY[1..3] OF INTEGER;
    bufferaddress = ^buffermemory;

PROCEDURE SaveRegion(VAR buff : bufferaddress;
                         x1,y1,  {upper left}
                         x2,y2   {lower right}
                               : INTEGER);

{---------- Local functions to SaveRegion-----------}

   FUNCTION max(a,b: INTEGER) : INTEGER;
      BEGIN
         IF a<b THEN max := b  ELSE max := a
      END;

   FUNCTION min(a,b : INTEGER) : INTEGER;
      BEGIN
         IF a<b THEN min := a  ELSE min := b
      END;

{---------- End local functions --------------------}

VAR   width, height, size : INTEGER;
          dummy1, dummy2 : BYTE;

BEGIN  {SaveRegion}

  {correct for negative x and y}
  x1 := max(x1,0); x2 := max(x2,0);
  y1 := max(y1,0); y2 := max(y2,0);

  {correct for large y}
  y1 := min(y1,199);  y2 := min(y2,199);

  {compute height of image in pixels}
  height := ABS(y1-y2) +1;

  CASE CRTmode(dummy1, dummy2) OF
           { dummy1 and dummy2 not used }
   4,5: {one of the low resolutions}
       BEGIN
          x1 := min(x1,319);  x2 := min(x2,319);

          {compute width of image in pixels}
          width := ABS(X1-X2) +1;

          {compute size of buffer need to store image}
          size := ((width+3) DIV 4) * height * 2  + 6;

          GETMEM(buff, size);
          GETPIC(buff^, x1,y1,x2,y2)
       END;

    6: {high resolution}
      BEGIN
          x1 := min(x1,639);  x2 := min(x2,639);
          width := ABS(x1-x2) +1;
          size := ((width+7) DIV 8) * height  + 6;
          GETMEM(buff, size);
          GETPIC(buff^, x1,y1,x2,y2)
      END;
    ELSE WRITE(^G); {unacceptable mode}
  END  {CASE}
END;  {SaveRegion}
```

End Listing One

Listing Two

```
    @Listing 2@.  The @CRTmode@ function determines which
    display mode is currently active.  It returns an integer
    code as well as two arguments which determine text row
    and column information if a text mode is active.
```

```
FUNCTION CRTmode(VAR  char_columns,
                      display_page : BYTE) : BYTE;

 {Returns CRT mode of operation.  It uses registers and
 software interrupt 10h to BIOS video services.  Also
 returns the number of character columns in the current
 video mode (80 or 40) and the video display page as
 VARiable parameters.

Version:  2
 Author:  H. D. Callihan, PhD,  UPJ
   Date:  2/29/87
   File:  CRTMODE.INC

VIDEO MODES:
     0 = 40x25 monochrome
     1 = 40x25 color
     2 = 80x25 monochrome
     3 = 80x25 color
     4 = 320x200 color graphics (40x25 text)
     5 = 320x200 mono graphics  (40x25 text)
     6 = 640x200 b/w high res graphics (80x25 text)

 The following values are returned on the AT&T 6300 for
 superres mode (640x400).

  $40 = 640x400 mono superres graphics
        (80x25 high quality text)

  $48 = 640x400 mono superres graphics
        (80x50 tiny text)

 Register input :   (AH) <-- 0Fh
 Register output:   (AL) --> current mode
                    (AH) --> number of character
                             columns on screen
                    (BH) --> current active display page

 Uses software interrupt 10h for BIOS video service.
 }

  TYPE regpack = RECORD
          ax,bx,cx,dx,bp,si,di,ds,es,flags: INTEGER
       END {regpack};

  VAR  dosreg : regpack;

  BEGIN       {CRTmode}
     WITH dosreg DO
        BEGIN
          {set high byte $0F for register input}
          ax := $0F00;
               { $0F = 00001111 binary}

          INTR($10, dosreg);   {software interrupt 10h}
          CRTmode := LO(ax);   {mask low byte}
          char_columns := HI(ax); {mask high byte}
          display_page := HI(bx)  {mask high byte}
        END
  END;       {CRTmode}
```

End Listing Two

Listing Three

```
 @Listing 3@.  The @RestoreRegion@ procedure copies any
 upright rectangular graphics screen region from a
 buffer, @buff@, previously saved by @SaveRegion@ where
 its lower-left screen coordinates (x,y) are specified.
 FREEMEM is used, rather than the standard DISPOSE,
 because the buffer size needs to be computed at run
 time.


PROCEDURE RestoreRegion
 (VAR buff : bufferaddress; {pointer}
          x,y : INTEGER;    {lower left corner}
       freeup : BOOLEAN);   {freemem after restore}

VAR width, height, resolution, size : INTEGER;
                          x_ok, y_ok : BOOLEAN;
BEGIN
   resolution := buff^[1];
   width := buff^[2];
   height := buff^[3];

   {check screen boundary y limits}
   y_ok := (y-height+1 >= 0) AND (y < 200);

   CASE resolution OF
     2: {low}
         BEGIN
          {check x limits}
          x_ok := (x >= 0) AND (x+width-1 < 320);

          IF x_ok AND y_ok THEN
          BEGIN
             PUTPIC(buff^,x,y);
             IF freeup THEN
             BEGIN
                size :=
                   ((width+3) DIV 4) * height * 2 + 6;
                FREEMEM(buff, size)
```

(continued on next page)

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Listing Three

(Listing continued, text begins on page 38.)

```
               END
            END
         END;
     1: {high}
         BEGIN
            x_ok := (x >= 0) AND (x+width-1 < 640);
            IF x_ok AND y_ok THEN
            BEGIN
               PUTPIC(buff^,x,y);
               IF freeup THEN {free the buffer}
               BEGIN
                  size :=
                     ((width+7) DIV 8) * height  + 6;
                  FREEMEM(buff, size)
               END
            END
         END;
     ELSE WRITE(^G^G)
   END  {CASE}
END;   {RestoreRegion}
```

End Listing Three

Listing Four

```
  @Listing 4@.  The @FreeBuffer@ procedure permits memory to
  be freed dynamically without displaying the image on the
  screen.  Like @RestoreRegion@, it also requires that the
  size of the memory block be computed based upon the
  block previously saved by @SaveRegion@.

PROCEDURE FreeBuffer ( VAR buff : bufferaddress );

VAR resolution, width, height, size : INTEGER;

BEGIN
   resolution := buff^[1];
   width := buff^[2];
   height := buff^[3];

   CASE resolution OF
      2 : {LOW}
          size := ((width+3) DIV 4) * height * 2 + 6;
      1 : {HIGH}
          size := ((width+7) DIV 8) * height  + 6;
      ELSE WRITE(^G^G^G)
   END; {CASE}
   IF resolution IN [1,2] THEN FREEMEM(buff, size)
END;  {FreeBuffer}
```

End Listing Four

Listing Five

```
  @Listing 5@.  The procedure, @SaveBlockToDisk@, facilitates
  saving a screen region to disk that was previously
  stored in a memory buffer using @SaveRegion@.  The file
  name is passed into the procedure as a string argument.
  @GetBlockFromDisk@ is a procedure which does the opposite
  by retrieving a block from disk and placing it into
  contiguous memory located at @buffer@.  @Resolution@ and
  @size@ are also computed and returned as a matter of
  convenience.  This recovered region may now be placed
  onto the screen using @RestoreRegion@.

{H D CALLIHAN, UNIVERSITY OF PGH AT JOHNSTOWN, 1987}

TYPE FileString80 = STRING[80];
PROCEDURE SaveBlockToDisk
   ( FileName : FileString80;
       buffer : bufferaddress  {mem address of block}
   );

VAR
     size, resolution, width, height : INTEGER;
     FileVariable : FILE;               {untyped file}

BEGIN
   resolution := buffer^[1];
   width := buffer^[2];
   height := buffer^[3];

   CASE resolution OF
      1 :  {HIGH}
           size := ((width + 7) DIV 8) * height + 6;
      2 :  {LOW}
           size := ((width + 3) DIV 4) * height *2 + 6;
      ELSE WRITE (^G^G^G^G)
   END:  {CASE}

   IF resolution IN [1,2] THEN BEGIN
```

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```
      ASSIGN ( FileVariable, FileName );
      REWRITE ( FileVariable );
      BLOCKWRITE ( FileVariable, buffer^, 1+(size-1) DIV 128 );
      CLOSE ( FileVariable )
    END {IF}
  END;  { BlockSave }


PROCEDURE GetBlockFromDisk
    ( FileName    : FileString80;
  VAR buffer      : bufferaddress;
  VAR resolution,  {1=hi, 2=lo}
      size         : INTEGER );

VAR
   FileVariable : FILE;
   width, height,
   SizeOfFile    : INTEGER;
      {number of 128-byte records in block file}

BEGIN
   ASSIGN ( FileVariable, FileName );
   RESET ( FileVariable );
   SizeOfFile := FILESIZE ( FileVariable );

   IF SizeOfFile <> 0 THEN BEGIN
      GETMEM( buffer, SizeOfFile * 128 );
      BLOCKREAD ( FileVariable, buffer^, SizeOfFile );
      resolution := buffer^[1];
      width := buffer^[2];
      height := buffer^[3];
      CASE resolution OF
        1 : {HIGH}
            size := ((width+7) DIV 8)*height   +6;
        2 : {LOW}
            size := ((width+3) DIV 4)*height*2 +6;
        ELSE WRITE(^G^G^G^G^G)
      END {CASE}
  END;  {IF}
  CLOSE ( FileVariable );
END;    {GetBlock}
```

End Listing Five

Listing Six

```
    @Listing 6@.  The following program demonstrates the use
    of @SaveRegion@ and @RestoreRegion@.  Figure 2 contains
    images saved in @buffer@ and @buffer2@.


PROGRAM Test_SaveRegion_and_RestoreRegion;

{$I graph.p}       {-->    extended Turbo Graphics}

{$I crtmode.inc}   {-->    Callihan function to check
                           current crt mode}
{$I gregion4.inc}  {-->    Callihan save and restore
                           region Turbo Code
                           and FreeBuffer code}

VAR         i  : INTEGER;
    buffer,
    buffer2    : bufferaddress;
      {TYPE declared in the above Callihan file.}

      {The TYPE must be used here for SaveRegion,
      RestoreRegion, and FreeBuffer to work.    }

BEGIN
   GRAPHCOLORMODE;              {Pick your resolution}
{   HIRES; }   { use only colors 0 and 1 if this is used}

   GRAPHWINDOW(50,100,200,180);
        {pick window: (50,100) to (200,180)}

   FILLSCREEN(2);
           {clear current window to green=1, black=0,etc.}
                                       {red=2,  yellow=3 }

{Now, draw lines in black=0, green=1, etc.}
{draw a nice border around the window}
   DRAW(148,78,148, 2, 3);
   DRAW(148, 2,  2, 2, 3);
   DRAW(  2, 2,  2,78, 3);
   DRAW(  2,78,148,78, 3);

{Now, let's draw a couple circles in the window
 with center and radius determined by a loop index.
 Use color as last parameter.}

   FOR i := 10 TO 25 DO CIRCLE(3*i, 2*i, i,  1);

   READLN;      {wait for user to press return}

   SaveRegion(buffer, 0,0,150,80);
        {saves in current window coords}
        {151 pixels wide by 81 high    }

{    GRAPHCOLORMODE;}   {this call clears and resets
                         window to full screen}

   FILLSCREEN(0);       {clear window to black,
                         don't reset to full screen}
```

(continued on next page)

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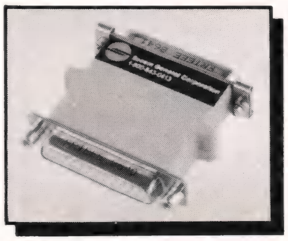

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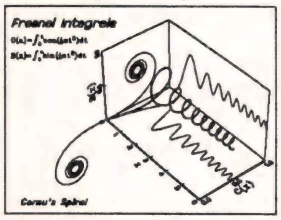

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TURBO PASCAL GRAPHICS

Listing Six

(Listing continued, text begins on page 38.)

```
READLN;

RestoreRegion(buffer,0,80,false);
     {Restores in current window coords }
     {at the lower left point 0,80      }
     {but does not free the buffer.     }

READLN;

GRAPHCOLORMODE;      {Pick resolution again}

{   HIRES;}

   RestoreRegion(buffer,0,80,false);

   READLN;

   FOR i := 1 TO 10 DO
        {let's get fancy}
        RestoreRegion(buffer,
                   150 - 8*i, 200 - 10*i, false);
   READLN;

   SaveRegion(buffer2,0,0,319,199);
           {Use buffer2 for background}

   FILLSCREEN(0);

   FOR i := 1 TO 10 DO BEGIN
      RestoreRegion(buffer, 10+4*i, 200-5*i, false);
      READLN;

      RestoreRegion(buffer2,0,199,false)
            {Restore background}
   END;  {for}

   READLN;

   TEXTMODE    {Return to the standard text screen}

END.
```

End Listings

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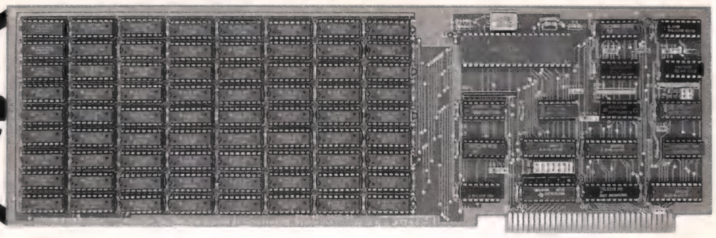

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Listing One *(Text begins on page 62.)*

```
/*  A C implementation Bickel's name comparison          */
/*  algorithm, CACM 30/3 (March 1987), p. 244.            */
/*  This is generic C code and should work on any          */
/*  compiler with no modification.                         */
/*  Jim Howell, March 1987.                                */

/*  This code is placed in the public domain.  You  are  */
/*  free to use it in any way you see fit.                 */


#include <ctype.h>
#include <stdio.h>


unsigned char    MaskArray [52] ={0, 0x40,          /*  a  */
                                 3, 0x80,          /*  b  */
                                 2, 0x20,          /*  c  */
                                 1, 0x10,          /*  d  */
                                 0, 0x20,          /*  e  */
                                 2, 0x10,          /*  f  */
                                 2, 0x08,          /*  g  */
                                 1, 0x08,          /*  h  */
                                 0, 0x10,          /*  i  */
                                 3, 0x08,          /*  j  */
                                 3, 0x20,          /*  k  */
                                 1, 0x04,          /*  l  */
                                 2, 0x04,          /*  m  */
                                 0, 0x08,          /*  n  */
                                 0, 0x04,          /*  o  */
                                 2, 0x02,          /*  p  */
                                 3, 0x10,          /*  q  */
                                 1, 0x02,          /*  r  */
                                 0, 0x02,          /*  s  */
                                 0, 0x01,          /*  t  */
                                 1, 0x01,          /*  u  */
                                 3, 0x40,          /*  v  */
                                 2, 0x01,          /*  w  */
                                 3, 0x04,          /*  x  */
                                 3, 0x02,          /*  y  */
                                 3, 0x01};         /*  z  */


/*  Demonstrate the algorithm with some short examples.  */
main ()
{
    unsigned char    LetterSet0 [4],
                     LetterSet1 [4];

    MakeLetterSet ("ecdysiast", LetterSet0);
    MakeLetterSet ("ecstasy", LetterSet1);
    printf ("The likeness of 'ecdysiast' and 'ecstacsy' is %d.\n",
      CompareSets (LetterSet0, LetterSet1));

    MakeLetterSet ("ectoplasm", LetterSet1);
    printf ("The likeness of 'ecdysiast' and 'ectoplasm' is %d.\n",
      CompareSets (LetterSet0, LetterSet1));

    MakeLetterSet ("edcysiast", LetterSet1);
    printf ("The likeness of 'ecdysiast' and edcysiast' is %d.\n",
      CompareSets (LetterSet0, LetterSet1));
    }    /*  main  */


/*  Make the letter set by going through the string       */
/*  one character at a time.                               */

MakeLetterSet (Name, Mask)
    char            *Name;
    unsigned char   *Mask;
{
    char            *pC;
    unsigned char   *pM;

int            I,
               Lk;

pC =Name;
for (I =0; I <4; ++ I)
    Mask [I] =0;
while (*pC)        {
    /*  Use letters only, and convert    */
    /*  uper to lower case.              */
```

```
        if (isalpha (*pC))      {
            pM =&MaskArray [2 *(tolower (*pC) -'a')];
            Mask [*pM] |=*(pM +1);
            }
        ++ pC;
        }
    }    /*  MakeLetterSet  */


/*  This particular version constructs a mask by using     */
/*  a logcal AND of the relevant bytes of the two sets.    */
/*  The rightmost bit is checked to see if the likeness    */
/*  score needs to be increased by the appropriate         */
/*  weight, and the mask is shifted right one bit.  An     */
/*  alternative would be to use a bit mask and to          */
/*  shift it instead of the name mask.  The two bytes      */
/*  of the least common letters are checked for content    */
/*  to eliminate any unnecessary calculations.             */

CompareSets (Set1, Set2)
    unsigned char    *Set1,
                     *Set2;
{
    unsigned char    Mask;
    int              I,
                     Lk;

    Lk =0;
    /*  For the first byte.  */
    Mask =Set1 [0] & Set2 [0];
    for (I =0; I <7; ++ I)      {
        if (Mask & 0x01)
            Lk +=3;
        Mask >>=1;
        }

    /*  The second byte.  */
    Mask =Set1 [1] & Set2 [1];
    for (I =0; I <5; ++ I)      {
        if (Mask & 0x01)
            Lk +=4;
        Mask >>=1;
        }

    /*  The third byte.  */
    Mask =Set1 [2] & Set2 [2];
    if (Mask)
        for (I =0; I <6; ++ I)      {
            if (Mask & 0x01)
                Lk +=5;
            Mask >>=1;
            }

    /*  The last byte is more complicated.  */
    Mask =Set1 [3] & Set2 [3];
    if (!Mask)
        return (Lk);
    if (Mask & 0x01)
        Lk +=9;                     /*  z  */
    Mask >>=1;
    if (Mask & 0x01)
        Lk +=8;                     /*  y  */
    Mask >>=1;

    if (Mask & 0x01)
        Lk +=8;                     /*  x  */
    Mask >>=1;
    if (Mask & 0x01)
        Lk +=8;                     /*  j  */
    Mask >>=1;
    if (Mask & 0x01)
        Lk +=7;                     /*  q  */
    Mask >>=1;
    if (Mask & 0x01)
        Lk +=7;                     /*  k  */
    Mask >>=1;
    if (Mask & 0x01)
        Lk +=6;                     /*  v  */
    Mask >>=1;
    if (Mask & 0x01)
        Lk +=6;                     /*  b  */
    Mask >>=1;

    return (Lk);
    }    /*  CompareMasks  */
```

End Listings

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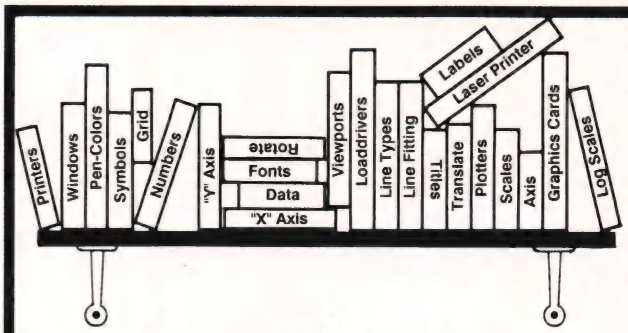

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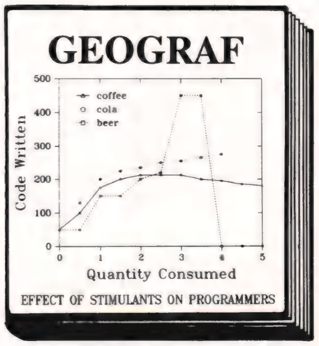

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Listing One *(Text begins on page 54.)*

```
        PUBLIC Lhandl_
        EXTERN c_ds,Hhandl_      ;See text for NEAR/FAR choice.
Lhandl_:
        pushf                    ;Push all registers. The order is
        push    ds               ;  arbitrary so long as it is known to the
        push    es               ;  interrupt function in Hhandl().
        push    bp
        push    si
        push    di
        push    dx
        push    cx
        push    bx
        push    ax
        mov     ds,cs:c_ds       ;Adjust DS and whatever other registers
                                 ;  your version of C requires.
        call    Hhandl_          ;Call high-level handler.
        pop     ax               ;Restore registers.  These may have been
        pop     bx               ;  altered by the interrupt function
        pop     cx               ;  called by the high-level handler.
        pop     dx
        pop     di
        pop     si
        pop     bp
        pop     es
        pop     ds
        popf
        ret       02             ;Substitute db 0cah,2,0 if a NEAR procedure
```

End Listing One

Listing Two

```
Hhandl(fake)
   int fake;
{
  REGS *regs = &fake;
  char serv;

  serv=regs->ax>>8;             /* preserve service # from caller's AH */
  interrupt(NEW16,regs);        /* chain to keyboard i/o bios routine */
  if(serv==0) switch(regs->ax){ /* if get-input service, test return */
     case HOTKEY1: hot1();       /* run through the hot keys */
       break;
     case HOTKEY2: hot2();
        break;
     case HOTKEY3: hot3()
        break;
     ...and so forth...
     }
}
```

End Listing Two

Listing Three

```
;interrupt(nn,pptr)
; int nn;
; REGS *pptr;
  PUBLIC interrupt_
interrupt_:
  push  bp
  mov   bp,sp                ;Set up base pointer for stack
  push  ds                   ;Push whatever registers need to be preserved
  mov   al,0cdh              ;CD (do-interrupt) machine code into low byte
  mov   ah,[bp+6]            ;Now reverse-byte AX reads "CDnn": nn=int#
  mov   cs:intnum[0],ax      ;Move interrupt code to instruction site
  lds   bx,[bp+8]            ;Load seg:ofs of struct pointer into DS:BX
  mov   ax,[bx+0]            ;Move structure's AX value into AX
  push  [bx+2]               ;Push final BX value onto stack
  mov   cx,[bx+4]            ;Load the rest, skipping BP & FLAGS
  mov   dx,[bx+6]
  mov   di,[bx+8]
  mov   si,[bx+10]
  mov   es,[bx+14]
  mov   ds,[bx+16]           ;Pointer gone: must pop BX
  pop   bx
  push  bp                   ;Somebody else may have stolen things beforehand
```

```
intnum: dw    00              ;Scene of crime of self-modifying code
  pop   bp
  push  bx                    ;Save returned DS & BX so we can use pointer
  push  ds
  lds   bx,[bp+8]             ;Load pointer
  mov   [bx+0],ax             ;Inverse of sequence above
  mov   [bx+4],cx
  mov   [bx+4],cx
  mov   [bx+6],dx
  mov   [bx+8],di
  mov   [bx+10],si
  mov   [bx+14],es
  pushf                       ;Must consider flags this time
  pop   [bx+18]               ;Flags into flags slot
  pop   [bx+16]               ;DS into structure
  pop   [bx+2]                ;And BX
  pop   ds                    ;Recover preserved registers
  pop   bp
  ret
```

End Listing Three

Listing Four

```
;chgint(old,new,lowhandler)
; int old,new,(*lowhandler)(); /*old vector, new, pointer to handler*/
   PUBLIC chgint_
chgint_:
  push bp
  mov  bp,sp                ;Set up base pointer to stack
  push ds
  mov ah,35h                ;First check to see if new vector is in use
  mov al,[bp+8]             ;Destination interrupt # into AL
  int 21h                   ;Present vector contents into ES:BX
  mov ax,es                 ;Set up for possible error return in AX
  or  ax,bx                 ;Are both seg & offset zero?
  jnz error                 ;if so, report error and exit
  mov ah,35h                ;Get-vector service again
```

(continued on next page)

Listing Four *(Listing continued, text begins on 54.)*

```
    mov al,[bp+6]          ;Old interrupt # into AL
    int 21h                ;Pick up "old" in ES:BX
    mov ax,es              ;ES:BX->DS:DX for function 25h call
    mov ds,ax
    mov dx,bx
    mov ah,25h
    mov al,[bp+8]          ;Interrupt destination into AL
    int 21h                ;Load DS:DX into table at "new"
    lds dx,[bp+10]         ;Low load pointer to low-level handler
    mov ah,25h
    mov al,[bp+6]          ;Old int# into AL again
    int 21h                ;Put function pointer into table
    pop ds                 ;Restore registers
    pop bp
    mov ax,0               ;return of zero in AX means O.K.
error:  ret
```

End Listing Four

Listing Five

```
#include <regsdef.h>          /* typedef of REGS structure */
#define OLDINT  XX            /* interrupt captured */
#define NEWINT  YY            /* new location for old vector */
/******************************/
Hhandl(xx)
 int xx;
{
 REGS *regs = &xx;
/*
*  Do whatever it is here that needs to be done. Obviously, other
*  C functions could be called from this one. Don't forget to chain
*  the interrupt so that other resident programs get their chances.
*  If a hardware interrupt is being captured and your handler is fairly
```

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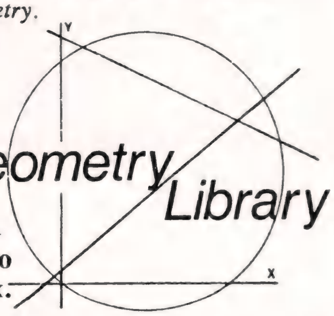

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```
*  lengthy, you may need to set a static flag to block reentry and
*  include _inb(0x20,0x20)--an EOI to the PIC.
*/
}
/****************************/
main()          /* Initialization routine */
{
  int Lhandl();  /* tell the compiler about the low-level handler */
  REGS rr;       /* allocate space for initializers's interrupt calls */

  saveds();                    /* save data segment */
  /*
  *  Set up the high-level handler here by initializing globals--e.g.,
  *  screen parameters, addresses in the 00:400h memory area, strings for
  *  hot-key substitutions, a pointer to the DOS-can-be-interrupted flag,
  *  a pointer to the  memory allocation chain, etc. Do it now, in C,
  *  while you are not in residence.
  */
  if(chgint(OLDINT,NEWINT,Lhandl))     /* test & swap vectors */
    puts("\n\nVECTOR IN USE\7\7");
  else{
     rr.ax = 0x3100;                   /* exit, stay resident service. */
     rr.dx = PROGRAMSIZE;              /* PROGRAMSIZE in paragraphs */
     puts("\n\nDONE & INSTALLED");
     interrupt(0x21,&rr);
     }
}
```

End Listings

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Listing One *(Listing continued, text in October.)*

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * ****
;_______________________________________________________________________
;
; MDoWarn -- Control call to put up a warning
;
; Entry:    A0 -> IOQelement
;_______________________________________________________________________

MDoWarn     move    CSParam(a0),D0      ; get the error code into D0
            bsr.s   DoWarn              ; warn 'em and return status in D0
            bra     AbusExit            ; and exit

; Put up alerts
;________________________________________________________________
;
;   DoWarn -- Warn the user...  Give a beep, and display a dialog;
;             wait for their choice, then try the NNNN one more time.
;             If they choose "Use new address" from Mismatch dialog,
;             set SysLAPaddr and SysNetNum to zero before exiting.
;
;   Entry:   D0 = PortNotCf
;                 noAnswer
;   Exit:    D0 = -4001 (user clicked OK/Try again)
;   -4002  (user clicked Use New)
;  -193  (ResFNotFound)
;________________________________________________________________

resfile     EQU     -2                  ; res file number
dlgwindow   EQU     -6                  ; dialog window handle
warning     EQU     -8                  ; error number/return status
MyCurMap    EQU     -10                 ; save the current res file

DoWarn      _SUBR   10                  ; Warn the user about troubles

            move.w  D0,warning(A6)      ; remember the warning
            move.w  CurMap,MyCurMap(A6) ; and the current res file
            InitCursor                  ; make it an arrow again

; Open our resource file.

            subq.l  #2,sp               ; make space for result
            pea     fileName            ; point to file name
            OpenResFile
            move.w  (SP)+,resfile(A6)   ; save the resfile number
            cmp.w   #-1,resfile(a6)     ; check for failure
            bne.s   @3                  ; branch if ok
            move.w  #60,-(A7)           ; else beep (long)
            SysBeep
            move.w  #ResFNotFound,D0    ; return bad status
            bra.s   @20                 ; and quit

; beep at 'em
@3
            move.w  #6,-(A7)            ; 1/10 second beep
            _SysBeep

; choose a dialog to display
            move.w  #PortNCalrt,D0
            cmp.w   #PortNotCf,warning(a6) ; which warning?
            beq.s   @5
            move.w  #Noansalrt,D0       ; noAnswer dialog

; now display the dialog
@5
            subq.l  #4,sp               ; space for result of _GetNewDialog
            move.w  D0,-(sp)            ;    dialog resource ID
            clr.l   -(sp)               ;    dialog record in heap
            move.l  #-1,-(sp)           ;    in front of other windows
            _GetNewDialog
            move.l  (SP)+,dlgwindow(A6) ; save the dialog's handle

;  Now do the dialog stuff

            subq.l  #2,sp               ; result on stack
            clr.l   -(sp)               ; normal filterproc
            pea     4(sp)               ; point to result space
            _ModalDialog                ;    Do it

; discard dialog
```

```
          move.l  dlgWindow(a6),-(sp) ; point to dialog
          _DisposDialog

; What did they hit?

          move.w  (sp)+,d0            ; get the button's item #
          cmp.w   #1,D0               ; (Try Again or OK (=1)) or Use New?
          beq.s   @10                 ; go if not "Use New"
          clr.b   SysLAPAddr(a2)      ; otherwise, Use New
          clr.w   SysNetNum(a2)       ;   and reset net and node adrs

@10       neg.l   D0                  ; item will be 1 or 2; return -4001
          sub.l   #4000,D0            ;      or -4002 as the status
          move.w  D0,warning(A6)      ; save it

; discard resource file

          move.w  resfile(A6),D0      ; get the refnum
          cmp.w   MyCurMap(A6),D0     ; was it the current resource file
          beq.s   @15                 ; go if so (someone else opened it)
          move.w  D0,-(sp)            ; else, push it
          CloseResFile                ; and close it
@15       move.w  warning(A6),D0      ; get the status from the NNNN

@20  ; D0 is result code for this routine
         _SUBEND 'DOWARN  '           ; and exit

FileName  DC.B    15
          DC.B    'Async AppleTalk'
          DC.B    'V1.2a6'
          ALIGN   2

; ****** end of lap.a
```

End Listing One

Listing Two

```
CRC Calculations

     This file contains a CRC calculation in Pascal.  It was used with
     preliminary versions of Async AppleTalk, and computes the same
     function as the code in the M68000 listing.

     The NextCRC algorithm simulates the feedback shift register which
     normally implements a CRC calculation.  NextCRC takes each four-
     bit nibble of the input char and uses a table (crctbl) to select
     a mask which is exclusive-or'd with the current CRC accumulator.
}

{ pseudo-CONST -- put this in the initialization code of your program

crctbl[00] := $0000; crctbl[01] := $CC01;
crctbl[02] := $D801; crctbl[03] := $1400;
crctbl[04] := $F001; crctbl[05] := $3C00;
crctbl[06] := $2800; crctbl[07] := $E401;
crctbl[08] := $A001; crctbl[09] := $6C00;
crctbl[10] := $7800; crctbl[11] := $B401;
crctbl[12] := $5000; crctbl[13] := $9C01;
crctbl[14] := $8801; crctbl[15] := $4400;
}

VAR crctbl : array [0..15] of integer;

function NextCRC (crc : integer; c : QDbyte) : integer;

VAR
     j : integer;

BEGIN
     j := crctbl[ band(bxor(crc,c),$000F) ];
     crc := bxor(bsr(crc,4),j);
     c := bsr(c,4);
     j := crctbl[ band(bxor(crc,c),$000F) ];
     crc := bxor(bsr(crc,4),j);
     nextcrc := crc;
END; { NextCRC }

function crc16 (p : qdptr; len : integer) : integer;
```

(continued on next page)

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Listing Two *(Listing continued)*

```
VAR
   i,j : integer;      { sixteen bits wide }
   c   : qdbyte;       { an eight bit value }
   crc : integer;      { the CRC accumulator }

BEGIN
   crc := 0;
   for i := 1 to len do begin
       c := p^;
       p := pointer(ord(p) + 1);
       crc := NextCRC(crc,c);
   end;
   crc16 := crc;
END; { crc16 }
```

End Listing Two

Listing Three

```
;
; _AssumeEq  Arg1, Arg2 -- macro to generate a compile-time error if two
;                          arguments are unequal.
;
;         To optimize code size, we will be making various assumptions,
;         mainly as to offset values. This macro is a way of formalizing
;         those assumptions within the code.
;

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          MACRO
          _AssumeEq
               IF  &Eval(&Syslst[1]) <> &Eval(&Syslst[2]) THEN
                   _ERR            ; Invalid statement - will cause error
               ENDIF
          ENDM
;
```

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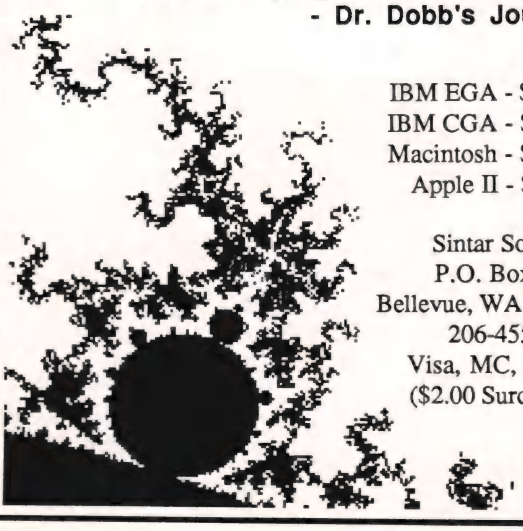

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```
; _StatCount Arg1 -- increment a statistics count if stat keeping is enabled
;
;          Assumes A2 points to the driver variables
;

           MACRO
           _StatCount
                IF  debug THEN
                     ADDQ.L  #1,&Syslst[1](A2); Update the count
                ELSE
.*                   nop   ; commented out
                ENDIF
           ENDM

;
; _Subr         -- assembles a "Link A6,#???"
;                  works for _SUBR <no param>   and   _SUBR ###
;
           MACRO
           _Subr     &size
           IF        &size = '' THEN
           Link      A6,#0
           ELSE
           Link      A6,#(-&size)
           ENDIF
           ENDM

;
; _Subend  NAME,$xx  -- Subroutine epilog
;                          If debugging, put in Unlk and the name
;
           MACRO
           _Subend &name
           Unlk      A6         ; unlink the stack frame
           rts                  ; and return
           DC.B      &name      ; the name
           ALIGN     2
           ENDM
```

End Listings

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Listing One

(Listing continued, text begins on page 116.)

```
              Listing 1 -- calendar.c, Printed 12/31/1987

#include <stdio.h>
#include <time.h>
#include <ctype.h>
/*------------------------------------------------------------
 * CALENDAR.C   This program searches a file called "calendar"
 *              in the current directory and prints all lines
 * that start with today's or tomorrow's date. Note that this
 * behaviour differs from Unix, which allows the date to be
 * anywhere on the line. Leading whitespace on the line is
 * ignored, however. Like Unix, "tomorrow" is extended to
 * Monday if calandar is run on a weekend.
 *
 * If the date is a weekday (monday, tuesday, wednesday),
 * which can be abbreviated by the first few character of the
 * name (mon, tu, wed) then the line is printed on that day,
 * reguardless of the actual date. For example, lines starting
 * with "tue" will be printed every tuesday. Explicit dates
 * can be listed too and most common abreviations work:
 *
 *              Sept. 7, 1987
 *              September 7 '87
 *              sept. 7
 *              Sep 7 87
 *              9-7
 *              9/7
 *              9/7/87
 *              9 7 1987
 *              9-7-1987
 *
 * and so forth. Like unix, "7 September" doesn't work, however.
 * The day must follow the month.
 *
 * If a * is found in the month's section of any of the above
 * dates (as in "*-7-87" or "* 7)" then that day in any month
 * will match. If no day is specified, then all days in the
 * indicated month will match.
 *
 * Abbreviations are formed by looking at the first few
 * characters of the word. The shortest possible abbreviations
 * are:
 *
 *              su      sunday          mo      monday
 *              tu      tuesday         w       wednesday
 *              th      thursday        fr      friday
 *              sa      saturday        ja      january
 *              fe      february        mar     march
 *              ap      april           may     may
 *              jun     june            jul     july
 *              au      august          se      september
 *              o       october         n       novemeber
 *              d       december
 *
 * BUGS: * If you specify both the day of the week and the date,
 *         as in "Tuesday, July 7, 1987", the "Tuesday" is
 *         processed and the date is ignored.
 *
 *       * The following won't work:
 *                      Jun 1   49er's today
 *        because calendar will pick off 49 as the current year.
 *        Put some nonnumeric character that can't be part of a
 *        date string in front of the "49." You can use any
 *        character but a number or one of: ( - . / ' ).
 */

#define JAN     31      /* Days in the month    */
#define FEB     28
#define MAR     31
#define APR     30
#define MAY     31
#define JUN     30
#define JUL     31
#define AUG     31
#define SEP     30
#define OCT     31
#define NOV     30
#define DEC     31

int offset_to_first_of_month[] =
{
        0,                              /* Offset to the first of */
        JAN,                               /* of the month from  */
        JAN +FEB,                             /* January, 1st.  */
        JAN +FEB +MAR,
        JAN +FEB +MAR +APR,
        JAN +FEB +MAR +APR +MAY,
        JAN +FEB +MAR +APR +MAY +JUN,
        JAN +FEB +MAR +APR +MAY +JUN +JUL,
        JAN +FEB +MAR +APR +MAY +JUN +JUL +AUG,
        JAN +FEB +MAR +APR +MAY +JUN +JUL +AUG +SEP,
        JAN +FEB +MAR +APR +MAY +JUN +JUL +AUG +SEP +OCT,
        JAN +FEB +MAR +APR +MAY +JUN +JUL +AUG +SEP +OCT +NOV
};

/*-------------------------------------------------------------*/

char    *skipstuff(p)
char    *p;
{
    /* All of the following can be used in a date string */

    while(isspace(*p)||*p=='-'||*p=='/'||*p=='.'||*p==','
                                                ||*p=='\'')
        ++p;

    return p;
}

/*-------------------------------------------------------------*/

main()
{
    char        buf[132], *p;
    FILE        *fd;
    struct tm   *t;
    long        thetime;
    int         month, day, year, wday;
    int         c1, c2, c3;

    if( !(fd = fopen("calendar", "r") ) )
    {
        perror( "calandar" );
        exit(1);
    }

    thetime = time(NULL) ;
    t = localtime( &thetime );
    printf("Today is %s\n", asctime( t ) );

    while( fgets( buf, 132, fd ) )
    {
       wday  = -1;
       month = -1;
       day   =  0;
       year  =  0;
       p     = buf;

       while( isspace(*p) )
               ++p;

       if( isalpha(*p) )
       {
           c1 = tolower( p[0] );
           c2 = tolower( p[1] );
           c3 = tolower( p[2] );

           if      ( c1=='a' && c2=='p'              ) month = 3 ;
           else if( c1=='a' && c2=='u'              ) month = 7 ;
           else if( c1=='d'                         ) month = 11;
           else if( c1=='f' && c2=='e'              ) month = 1 ;
           else if( c1=='f' && c2=='r'              ) wday  = 5 ;
           else if( c1=='j' && c2=='a'              ) month = 0 ;
           else if( c1=='j' && c2=='u' && c3=='l' ) month = 6 ;
           else if( c1=='j' && c2=='u' && c3=='n' ) month = 5 ;
           else if( c1=='m' && c2=='a' && c3=='r' ) month = 2 ;
           else if( c1=='m' && c2=='a' && c3=='y' ) month = 4 ;
           else if( c1=='m' && c2=='o'              ) wday  = 1 ;
           else if( c1=='n'                         ) month = 10;
           else if( c1=='o'                         ) month = 9 ;
           else if( c1=='s' && c2=='a'              ) wday  = 6 ;
           else if( c1=='s' && c2=='e'              ) month = 8 ;
           else if( c1=='s' && c2=='u'              ) wday  = 0 ;
           else if( c1=='t' && c2=='h'              ) wday  = 4 ;
           else if( c1=='t' && c2=='u'              ) wday  = 2 ;
           else if( c1=='w'                         ) wday  = 3 ;

           if( wday >0 )
           {
               if( t->tm_wday == wday || (t->tm_wday +1) == wday)
                   fputs( buf, stdout );

               continue;
           }

           while( isalpha( *p ) || *p == '.' )
                   p++;

           p = skipstuff(p);
       }

       if( isdigit( *p ) || *p == '*' )
       {
           if( *p == '*' )
           {
               month = t->tm_mon;
               ++p;
           }
           else if( month < 0 )
               month = stoi( &p ) - 1;

           p   = skipstuff(  p );
           day = stoi      ( &p );
           p   = skipstuff(  p );

           if( (year = stoi(&p)) > 99 )
                   year -= 1900;
       }

       if( !year      )   year  = t->tm_year ;
       if( month < 0 )   month = t->tm_mon  ;
       if( !day       )   day   = t->tm_mday ;

       /* Convert the specified date to an offset, in days,
        * from Jan 1. Unix provides the offset for today in the
        * tm_yday field. It makes life difficult by making 1 Jan.
        * be 0, however. We also have to compensate for leap
        * year. If the year is a multiple of 4, it's a leap year
        * unless it's also the first year of the century (1900
        * was not a leap year, even though it's a multiple of 4).
        */

       day += offset_to_first_of_month[ month ] - 1;
       if( year % 4 == 0  &&  year % 100 != 0  && month >= 2 )
               day++;

```

(continued on page 110)

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Listing One

(Listing continued, text begins on page 116.)

```
        /* Print the line if required. The first test is the
         * normal situation (today or tomorrow). The second
         * test takes care of Saturday, which must include
         * the following Monday in its definition of "tomorrow."
         * The third test takes care of December 31, which must
         * recognize January 1 as "tomorrow." Note that I'm
         * intentionally not testing for the years being different
         * because it seems reasonable that, if no year is
         * specified and today is December 31, that the next year
         * is implied by January 1, with no date.
         */

        if( t->tm_year == year &&
                (day == t->tm_yday || day == t->tm_yday +1) )
            fputs( buf, stdout );

        if( t->tm_wday == 6  &&  day == t->tm_yday + 2 )
            fputs( buf, stdout );

        if( t->tm_mday == 31 && t->tm_mon == 11 && day == 0 )
            fputs( buf, stdout );
    }
}
```

End Listing One

Listing Two

```
Listing 2 -- dateh.c, Printed 7/26/1987
```

```
#include <stdio.h>
#include <dos.h>
#include <time.h>
#include <sys/types.h>
#include <sys/stat.h>

/*-------------------------------------------------------------
 *
 *      Creates or updates file called date.h that looks like:
 *
 *              #define _DAY_      "6-17-87"
 *              #define _TIME_24_  "12:5:23"
 *              #define _TIME_     "12:5 PM"
 *              #define _DATE_     "6-17-87 12:5 PM"
 *
 * and holds the current time and date. The file is  created
 * if it doesn't exist. If it does exist, it is modified, but
 * only if it was not modified or created earlier on the same
 * day. All of this behaviour can be modified by command-line
 * switches [see usage(), below].
 *
 * This program uses the Unix time functions. For them to work,
 * you need to set the various codes in the TZ environment
 * variable. For example:
 *              setenv TZ=PST8PDT               (Unix or Sh)
 *              set    TZ=PST8PDT               (COMMAND.COM)
 *
 * Says the Pacific Standard Time is 8 hours off of Greenwich
 * and the PST is used as the abbreviation for it. PDT is used
 * as an abbreviation for daylight savings time.
 *
 * Exit status is 0 if the file is untouched, 1 if it's created
 * or modified, 2 on an error of some sort.
 */

main( argc, argv )
char    **argv;
{
    FILE        *fd;
    struct stat stats;
    struct tm   *t;
    int         day ;
    long        thetime;
    int         pm;
    char        *p;

    int         verbose  = 0;
    int         force    = 0;
    int         create   = 0;

    if( argc != 1 )
    {
            p = argv[1];

            if( *p != '-' )
                usage();
            else
                for( ++p ; *p ; p++ )
                    switch( *p )
                    {
                    case 'v': verbose = 1;      break;
                    case 'f': force   = 1;      break;
                    case 'c': create  = 1;      break;
                    default : usage();
                    }
    }

    thetime = time(NULL) ;

    if( stat("date.h", &stats) != 0 )
    {
        if( !create )               /* File doesn't exist */
            exit( 0 );

        t = localtime( &thetime );
        printf("Creating DATE.H: %s\n", asctime(t) );
    }
    else
    {
        t = localtime( &(stats.st_mtime) );

        if( verbose )
            printf( "DATE.H last modified: %s", asctime(t) );

        day = t->tm_yday;

        t = localtime( &thetime );

        if( verbose )
            printf( "Today is: %s", asctime(t) );

        if( t->tm_yday == day && !force )
            exit( 0 );
        else
            printf("Modifying DATE.H\n");
    }

    if( !(fd = fopen( "date.h", "w" )) )
    {
            perror( "date.h" );
            exit( 2 );
    }
    else
    {
        fprintf(fd, "#define _DAY_      \"%d-%d-%d\"\n",
                                        t->tm_mon,
                                        t->tm_mday,
                                        t->tm_year );

        fprintf(fd, "#define _TIME_24_  \"%d:%d:%d\"\n",
                                        t->tm_hour,
                                        t->tm_min,
                                        t->tm_sec );

        pm = t->tm_hour >= 12;

        if( t->tm_hour > 12 )
                t->tm_hour -= 12;

        else if( t->tm_hour == 0 )
                t->tm_hour  = 12;

        fprintf(fd, "#define _TIME_     \"%d:%d %s\"\n",
                                t->tm_hour,
                                t->tm_min,
                                pm ? "PM" : "AM" );

        fprintf(fd, "#define _DATE_     \"%d-%d-%d %d:%d %s\"\n",
                                t->tm_mon,
                                t->tm_mday,
                                t->tm_year,
                                t->tm_hour,
                                t->tm_min,
                                pm ? "PM" : "AM" );
        fclose(fd);
    }

    exit( 1 );
}

/*-------------------------------------------------------------*/

#define E(x) fprintf(stderr,x)

usage()
{
    E("Usage dateh [-fvc]\n");
    E("If date.h doesn't exist, create it, otherwise if\n");
    E("the date stamp isn't today, update it\n");
    E("\n");
    E("-f  forces an update, even if the date stamp is ok\n");
    E("-v  verbose operation\n");
    E("-c  create file if it doesn't exist\n");
    E("\n");
    exit( 2 );
}
```

End Listings

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CIRCLE 227 ON READER SERVICE CARD

Listing One *(Text begins on page 124.)*

```
Listing 1.  Pascal function for the simple heuristic search in an
            unordered array.

FUNCTION Search1(VAR Data   : AnyArrayType; { input   }
                 VAR Index  : IntegerArray; { in/out  }
                     NData  : INTEGER;      { input   }
                     Item   : ScalarType    { input   }) : INTEGER;

{ function returns the index of the matching
  array, or zero if no match is found          }

VAR I, Tempo : INTEGER;

BEGIN
    I := 1;
    { scan array }
    WHILE (Item <> Data[ Index[I] ]) AND (I <= NData)   DO
            I := I + 1;

    IF I <= NData
    THEN BEGIN { match found }
        Search1 := Index[I]; { returned result }
        { Swap indices ? }
        IF I > 1 THEN BEGIN
            Tempo := Index[I];
            Index[I] := Index[I-1];
            Index[I-1] := Index[I];
        END { IF }
    END
    ELSE Search1 := 0; { not found }

END; { Search1 }
```

End Listing One

Listing Two

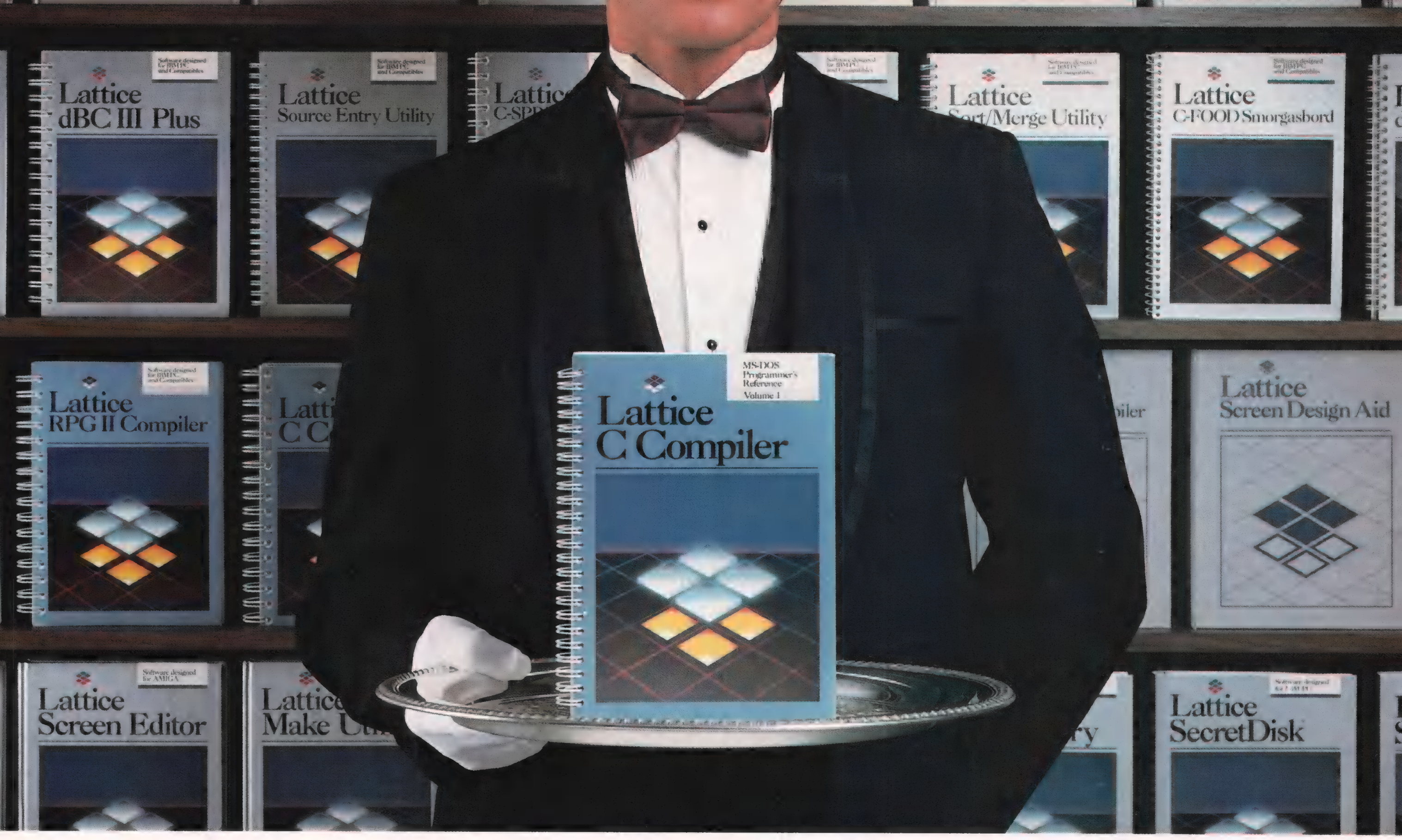
```
Listing 2.  Pascal function for the heuristic search method for
            unordered arrays.

FUNCTION Search2(VAR Data   : AnyArrayType; { input   }
                 VAR Index  : IntegerArray; { in/out  }
                 VAR Loctn  : SmallIntArray;{ in/out  }
                     NData  : INTEGER;      { input   }
                     Item   : ScalarType    { input   }) : INTEGER;

{ function returns the index of the matching
  array, or zero if no match is found          }

CONST Factor = 0.7; { time-series factor }
      { limits used to select search schemes }
      UPPER_LIMIT = 0.65; { = 0.5 + 0.15 }
      LOWER_LIMIT = 0.35; { = 0.5 - 0.15 }
      { number of Loctn elements used in predicting the next
        matching location }
      N = 4;

VAR Continue : BOOLEAN;
    I, J, Tempo, This_Location, Median,
    Skip, Result : INTEGER;
    Next_Location, Power : REAL;


PROCEDURE Swap_Indices(K : INTEGER);
{ Procedure used to swap indices }
BEGIN
    { Swap indices ? }
    IF K > 1 THEN BEGIN
        Tempo := Index[K];
        Index[K] := Index[K-1];
        Index[K-1] := Index[K];
    END { IF }
END;


BEGIN
    { Estimate the next location }
    Next_Location := 0.0; { initialize next location }
    Power := 1.0;
    FOR I := N DOWNTO 1 DO BEGIN
        Next_Location := Next_Location + Power * Loctn[I];
        Power := Power * Factor;
    END;
    { calculate predicted next search location as a fraction }
    Next_Location := (1.0 - Factor) * Next_Location   / NData;


    Result := 0; { default value for no match }

    IF Next_Location > UPPER_LIMIT THEN BEGIN
        { Search last-to-first }
        I := NData;
        WHILE (Item <> Data[ Index[I] ]) AND (I > 0)   DO
            I := I - 1;

        IF I > 0 THEN BEGIN
            Result := Index[I];
            Swap_Indices(I); { swap indices }
        END { IF }
    END
    ELSE IF Next_Location < LOWER_LIMIT THEN BEGIN
        { Search first-to-last }
        I := 1;
        WHILE (Item <> Data[ Index[I] ]) AND (I <= NData)   DO
            I := I + 1;
        IF I <= NData THEN BEGIN
            Result := Index[I];
            Swap_Indices(I); { swap indices }
        END { IF }
    END
    ELSE
        { Perform bidirectional search starting at the middle }
        Median := NData div 2;
        IF Item <> Data[ Index[Median] ] THEN BEGIN
            Skip := 1;
            Continue := TRUE;
            REPEAT
                I := Median + Skip;
                IF I <= NData THEN
                    IF Item = Data[ Index[I] ] THEN BEGIN
                        Result := Index[I];
                        Continue := FALSE;
                        Swap_Indices(I); { swap indices }
                    END; { IF }

                J := Median - Skip;
                IF J > 0 THEN
                    IF Item = Data[ Index[J] ] THEN BEGIN
                        Result := Index[J];
                        Continue := FALSE;
                        Swap_Indices(J); { swap indices }
                    END; { IF }

                IF (I > NData) AND (J < 1) THEN { out of bounds }
                    Continue := FALSE;

                Skip := Skip + 1;
                UNTIL (NOT Continue);

            END
            ELSE BEGIN
                Result := Index[Median];
                Swap_Indices(Media)
            END; { IF }
        END; { IF }

        IF Result > 0 THEN BEGIN
            { Update location array }
            FOR I := 1 TO N-1 DO
                Loctn[I] := Loctn[I+1];
            Loctn[N] := Result
        END; { IF }

        Search2 := Result; { return result }


END; { Search 2 }
```

End Listing Two

Listing Three

```
Listing 3.  Pascal code for function implementing the first
            heuristic search method for fixed ordered arrays.

PROCEDURE Initialize(VAR Data    : AnyArrayType; { input   }
                     VAR Table   : RecordArray;  { in/out  }
                     TableSize   : INTEGER;      { input   }
                         NData   : INTEGER       { input   });

{ initialize index table by inserting data at equal intervals }
{

    TYPE TableRecord = RECORD
            Key : ScalarType;
            Index : INTEGER;
         END;

         RecordArray = ARRAY[1..MAX_TABLE_SIZE] OF TableRecord;
}

VAR I, J, Delta : INTEGER;

BEGIN
    Delta := NData div TableSize;
    J := 1;
    FOR I := 1 TO TableSize DO BEGIN
        Table[I].Key := Data[J];
        Table[I].Index := J;
        J := J + Delta;
    END;

END; { initialize }



FUNCTION Search3(VAR Data   : AnyArrayType; { input   }
                 VAR Table  : RecordArray;  { in/out  }
                 TableSize,                 { input   }
                     NData  : INTEGER;      { input   }
                     Item   : ScalarType    { input   }) : INTEGER;

VAR Found, NoMatch : BOOLEAN;
    First, Last, I, K, Result : INTEGER;
```

(continued on page 115)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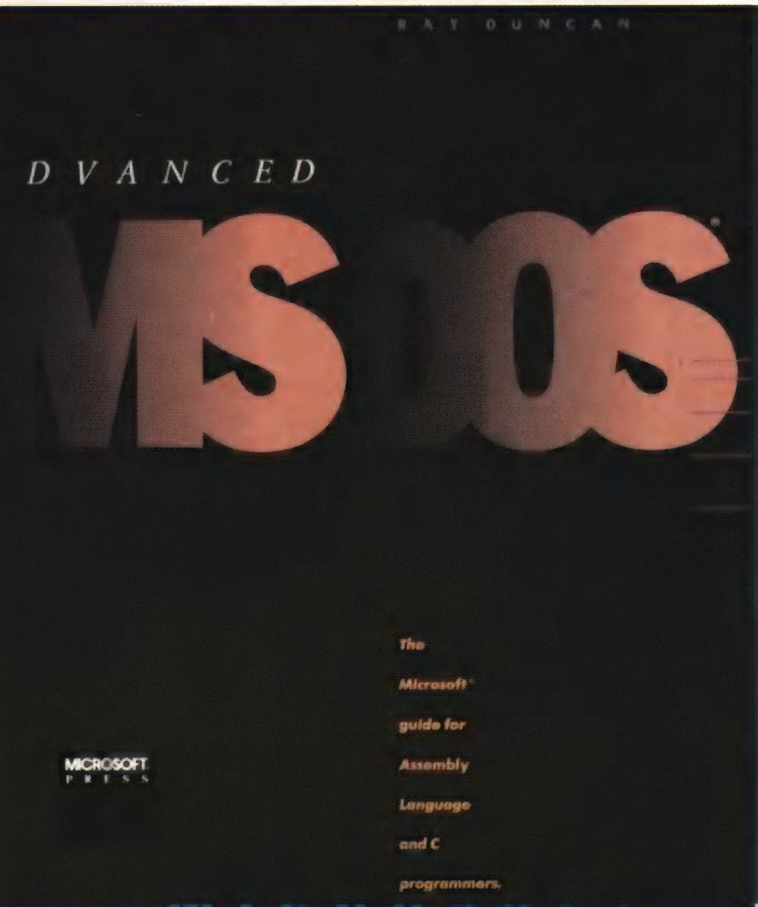
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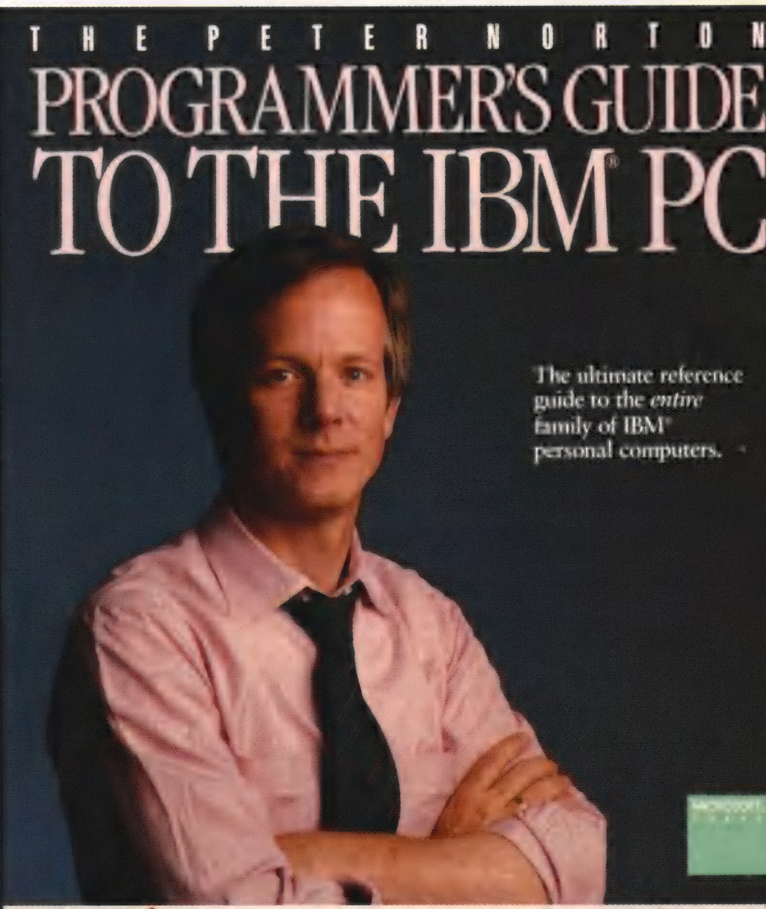
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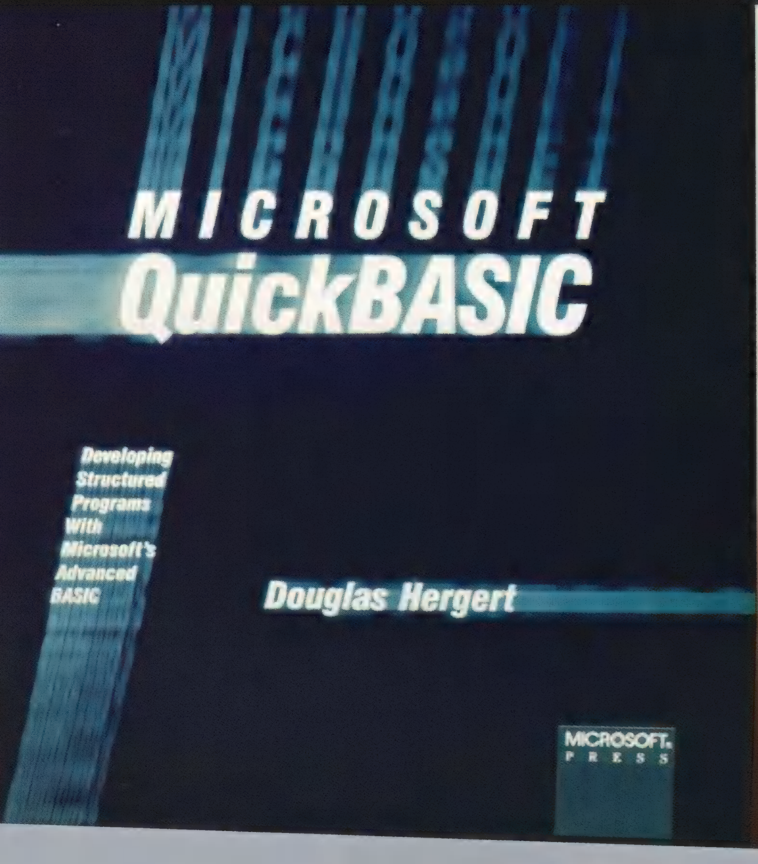
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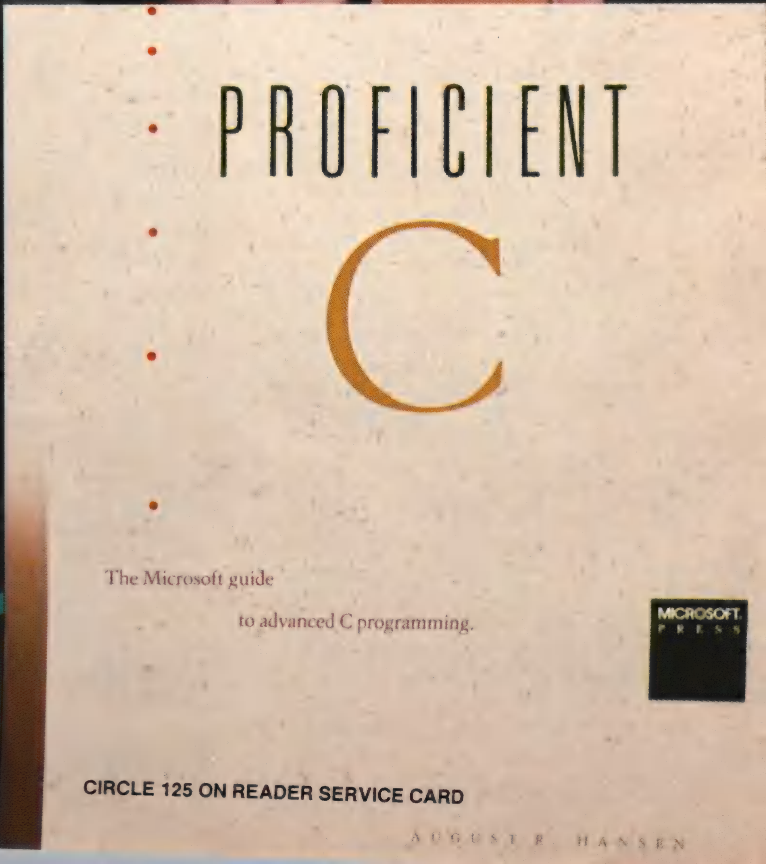

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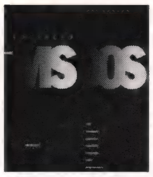

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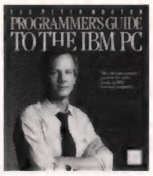

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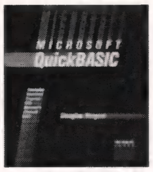

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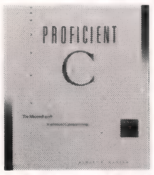

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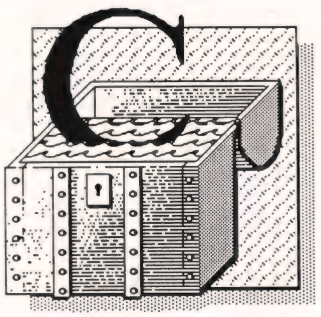
CIRCLE 125 ON READER SERVICE CARD

Listing Three *(Listing continued, text begins on page 124.)*

```
BEGIN
    Result := 0; { initialize result with default value }

    { Search for Item in index table }
    I := 1;
    WHILE (Item > Table[I].Key) AND (I <= TableSize) DO
        I := I + 1;

    Found := FALSE;

    IF I <= TableSize
        THEN Found := (Item = Table[I].Key)
        ELSE I := I - 1;

    IF Found
    THEN
        Result := Table[I].Index
    ELSE
        { Get range for search limits }
        First := Table[I-1].Index;
        Last := Table[I].Index;
        K := I-1;
        NoMatch := TRUE;
        I := First;
        WHILE (I <= Last) AND NoMatch DO
            IF Item <> Data[I].Key THEN I := I + 1
                                   ELSE NoMatch := FALSE;


        IF NOT NoMatch THEN BEGIN
            Result := Table[I].Index; { store result }

            IF K > 1 THEN BEGIN { update table entry }
                Table[K].Key := Item;
                Table[K].Index := Result
            END; { IF }

        END; { IF }

    END; { IF }

    Search3 := Result { return result }

END; { Search3 }
```

End Listings

Using the Unix/ANSI Time Functions



by Allen Holub

This month I'm going to look at the Unix (and now ANSI) time functions and demonstrate their use with two short but useful programs—calendar and dateh.

Calendar is an implementation of the Unix program of the same name. It searches a file called calendar and prints every line that starts with today's or tomorrow's date. If you put it into your AUTOEXEC.BAT file and put the calendar in your root directory, the program prints reminders of what you have to do on any given day when you start up your system.

The second program, dateh, creates (or modifies) a file called date.h to hold C *#define*s for a few strings that represent today's date and the time when dateh was run. You can use these *#define*s in a program's sign-on message to keep track of when the program was compiled. A sample dateh output file is shown in Example 1, below. The file is modified only if it already exists and if it hasn't been modified earlier today, though you can change this behavior with command-line switches. The default behavior facilitates using dateh along with a make utility. You can call it every time you compile, but you'll only have to recompile the file that *#include*s date.h once a day. Dateh returns an exit status of 1 if the file is modified (0 if it's not, 2 on a command-line syntax error). So, you can use the COMMAND.COM *ERRORLEVEL* mechanism (or my shell's[1] *$status* variable) in a batch file or shell script to decide whether or not to recompile.

The Time Functions

The Unix time functions provide a portable way to access the time and date from within a program. You can use them to get both time and date during execution of a program and the time-and-date stamp associated with a file. Because they have been incorporated into ANSI, they provide a degree of system independence not available if you do direct DOS calls. All these functions require an *#include <time.h>* at the top of your program.

There are two classes of time functions. The lowest-level function, called *time( )*, provides the time and date as the number of seconds elapsed since midnight, January 1, 1970 GMT. The returned value is of type *long*. Because there are roughly 31,557,600 seconds in a year (365.25 ×24×60×60), and because the largest (signed) 32-bit number that a *longint* can hold is 2,147,483,647, the time will roll over on January 18, 2038 at 2:56:02 a.m. This means, of course, that all Unix programs that use *time( )* will fail on in the morning of January 18, 2038—you can't have everything.

The ANSI standard differs from Unix in that the return value from *time( )* is an object of type *time_t* rather than *long* and *time_t* is left undefined. This means that a compiler manufacturer could *typedef time_t* as a *double*, for example, in order to move the rollover point well into the next century. I'll use the ANSI convention for the rest of this article. The ANSI calling syntax for *time( )* is:

```
time_t time( timeptr );
time_t *timeptr;
```

and the Unix syntax is:

```
long time( timeptr );
long *timeptr;
```

The *time( )* function always returns the current time. In addition, if *timeptr* is not *NULL*, it will also load the time into the object pointed at by *timeptr*. The function returns *((time_t)(–1))* if the calendar time isn't available.

A second low-level function that's useful in conjunction with the *time( )* function is *stat( )*. The calling syntax is:

```
#include <sys/types.h>
#include <sys/stat.h>

int stat( path, buf )
char *path;
struct stat *buf;
```

The first argument is the path name of a file; the second is a pointer to a structure declared in stat.h. *Stat( )* fills the structure with information about the file, such as the permission mask, file size, and so forth. There are three fields that are time related: *st_atime, st_mtime,* and *st_ctime.* These hold the file's date stamp, and they use the same elapsed-time-since-1970 mechanism that is used by *time( )*. In Unix systems, *st_atime* holds the time of last access, *st_mtime* is the time

```
#define _DAY_      "6-17-87"
#define _TIME_24_  "13:11:41"
#define _TIME_     "1:11 PM"
#define _DATE_     "6-17-87 1:11 PM"
```

Example 1 *Date.h file created by dateh*

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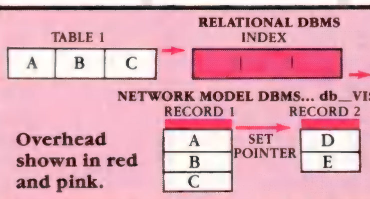

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(continued from page 116)

when the file was last modified, and *st_ctime* is the create time. In MS-DOS compilers such as Microsoft's, all three fields are set to the last-modified time because that's the only information available from DOS.

A related function, *fstat( )*, works rather like *stat( )* does, but it takes a *FILE* pointer as its first argument rather than a path name.

The *difftime( )* function returns the difference between two times, as returned by *time()* or *stat( )*. Its calling syntax is:

```
double difftime (t1, t2)
time_t t1, t2;
```

Note that the returned value is of type *double*, not *time_t*. *Difftime( )* is necessary because you do not know the actual type of a *time_t* (it may be a structure, for example). Consequently, you can't just subtract two times to get the difference if you want your code to be portable.

Note that the minimum resolution available from *time( )* is seconds. If you need fractional time, you need to use the *ftime( )* function. Its calling syntax is:

```
#include <sys/types.h>
#include <sys/timeb.h>

void ftime( timep )
struct timeb *timep;
```

The *timeb* structure is shown in Example 2, below. The two fields of interest are the *time* field, which holds the same value as would be returned from *time( )*, and the *millitm* field, which holds an additional number of milliseconds (thousandths of a second). Note that the resolution here is not better than your system clock. For example, the IBM PC clock ticks 18.2 times a second, so the maximum resolution on a PC is 54 milliseconds.

The second level of time functions all represent the time as a structure, also declared in time.h (and shown in Example 3, below).

Two functions—*gmtime( )* and *localtime( )*—convert the *time_t* times, as returned by *time( )* or *stat( )*, into *tm* structures. They both have the same calling syntax:

```
struct tm *gmtime ( time )
struct tm *localtime( time )

time_t *time_ptr;
```

Gmtime( ) converts to Greenwich Mean Time, and *localtime( )* goes to the current local time. Note that you're passing in a pointer to a variable that holds the time, not the time itself.

The local time is determined in mysterious ways, depending on your system. Most Unix systems have it hard-coded into the *localtime( )* function, which automatically figures out the peculiarities of daylight savings time and so forth. Many compilers, however, use an environment variable to determine the local time. For example, Microsoft's uses an environment variable called *TZ* for this purpose. It's set to a string something like *PST8PDT*, which says that Pacific Standard Time (PST) is 8 hours off Greenwich and that Pacific Daylight Time (PDT) is 1 hour off that. Microsoft provides a *tzset( )* function that can be used to set this environment variable from within a program. In Unix, the name of the current time zone is available through the *timezone( )* function. Consult the ctime(3) section of the manual for details.

The *mktime( )* function goes in the other direction. It takes as input a *tm* structure and returns the equivalent time in a *time_t*, as would have been returned by *time( )*. The calling syntax is:

```
time_t mktime(time_ptr)
struct tm *time_ptr;
```

Mktime( ) can also be used to flush out the *tm_mday* and *tm_yday* fields of the structure. That is, if you want to find out the day of the week for a particular day, you can fill up a *tm* structure yourself, leaving the *tm_wday* and *tm_yday* fields empty, and then *mktime( )* will modify those fields as required.

Three functions are provided for printing the time: *strftime( )*, *ctime( )*, and *asctime( )*. *Strftime( )* is an ANSI function, not supported by Unix, that works something like *sprintf( )* does. Because it's not implemented by most compilers, I won't discuss it further. Calling syntaxes for the other two functions are:

```
char *asctime( time )
struct tm *time;

char ctime( tp )
time_t *tp;
```

```
struct timeb
{
  time_t         time;     /* Time, like that returned from time().  */
  unsigned short millitm;  /* fraction of a second, in milliseconds */
  short          timezone; /* The difference moving westward, in    */
                           /* minutes, between Greenwich Mean Time  */
                           /* and the local time.                   */
  short          dstflag;  /* Nonzero if daylight savings time is   */
                           /* in effect.                            */
};
```

***Example 2** The* timeb *structure*

```
struct tm
{
    int tm_hour;        /* hour                          */
    int tm_min;         /* minute                        */
    int tm_sec;         /* second                        */
    int tm_isdst;       /* daylight savings time is active */
    int tm_year;        /* year - 1900                   */
    int tm_mon;         /* month; January == 0           */
    int tm_mday;        /* day of the month              */
    int tm_wday;        /* day of the week; Sunday == 0  */
    int tm_yday;        /* number of elapsed days since  */
                        /* January 1, January 1 == 0    */
}
```

***Example 3** A* tm *structure*

They both return a string that is exactly 26 characters long and has the following form:

```
Wed Jul 22 11:57:45 1987\n\0
```

Asctime() takes a pointer to a *tm* structure as its argument, as is returned from *gmtime()* or *localtime()*. *Ctime()* takes a pointer to a *time_t* argument, as is returned by *time()* or *stat()*. Note, again, that this argument is a pointer to a variable holding the time, not to the time itself.

Calendar.c

Calendar is a DOS version of the Unix memo program. It searches a file called calendar, which must be in the current directory, for lines starting with a date, and if that date is either today or tomorrow, it prints the line. Note that this behaviour differs from that of the Unix program, which allows the date to be anywhere on the line. My implementation ignores white space that precedes the date, but no other characters can be present. "Tomorrow" for weekends is extended to include the following Monday.

My calendar, unlike the Unix version, returns an exit status of 0 when it prints something (nonzero if it doesn't). I invoke it from the LOGIN.BAT file used by my shell with the following:

```
calendar
if( $status == 0 ) then
    bell
    bell
endif
```

Bell is a two-line program that rings the bell on the PC. This way I get both the message and an audible signal when I have something to do. You could do the same thing from within a COMMAND.COM batch file by using the *ERRORLEVEL* mechanism.

The program recognizes most forms of dates, though the date must take the form of month, then day, then year; neither *87-9-17* nor *17 Sept* is recognized. All the following are recognized, however:

```
Sept. 7, 1987
September 7 '87
Sep. 7
```

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COMMENTS & SUGGESTIONS

November 1987, #133

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(continued from page 119)

```
sep 7 87
9-7
9/7
9/7/87
9 7 1987
9-7-1987
```

as are several other variants. Experiment and see if your favorite form works. If you use an asterisk in place of a month, then that day of every month is recognized—for example */9 will be recognized on the ninth of every month.

I've also added a non-Unix feature that recognizes days of the week (*monday, tuesday, wednesday,* and so forth). When these are used, memos are printed on the given day of every week (say, every Monday).

You can abbreviate month and day-of-the-week names by leaving off letters at the ends of the words, but you can't leave off so many letters that a conflict is created. For example, you can't use *Ju* because the program won't know if you mean June or July. The smallest possible abbreviations are shown in Listing One, page 108, on lines 42–51. Case is ignored, so *SEP, sep,* and *Sep* are all acceptable.

Calendar gets confused if you start the text portion of the line with a character that could be part of the date and a partial date is specified. For example, if you say:

```
9/17 4 for feast at Fran's
```

calendar will think that the date is September 19, 1904.

```
9/17/87 4 for . . .
9/17: 4 for . . .
```

are both OK, however; the first because the whole date is specified, and the second because the colon will separate off any trailing numbers. In general, avoid numbers, slashes, apostrophes, dashes, and periods at the beginning of the memo text.

The program itself is in Listing One. Most of it is in the *main()* subroutine, which starts on line 110. Today's date is fetched on lines 125 and 126, using the *time()* and *localtime()* functions described earlier. Word-to-month conversion is done in the *if* statement on lines 140–178. The program just looks at the first few characters in the word in the stupidest way possible. It didn't seem worth the effort to do things in a more efficient manner.

Numeric parts of the date are split off on lines 180–195. Note that the month is only modified (on line 188) if it hasn't been set previously (by the word-processing code). An asterisk is translated to the current month on line 182. The *stoi()* subroutine has appeared in this column several times in the past (it's not part of this month's listing). It works just like *atoi()* does, but it is passed a pointer to a character pointer and updates that pointer to point past the number.

The tests on lines 198–200 check for unspecified parts of the date and fill in the equivalent information for today if necessary. That is, if the year isn't specified, the current year is used and so forth.

The date is converted to an offset, in days, from the first of the year on lines 211–213. I'm doing this to make it easier to find tomorrow. Otherwise, the end of the month would present problems. The *offset_to_first_of_month* array is declared on lines 78–92. The *if* statement on line 212 adjusts for leap years (any year that is an even multiple of 4 except for even centuries—1900 wasn't a leap year). Finally, the appropriate lines are printed on lines 227–235.

Dateh.c

The dateh program is used to automatically create *#defines* for the current date and time so that you can put a visible date stamp into a program's log-in message. You can put it into a DOS batch file so that it's invoked automatically before calling make. If you're using my shell, you can do it with an alias:

```
alias make 'dateh; make'
```

The output file was described earlier. It's created only when a file called date.h already exists in the current directory and it was not modified today. It behaves in this way for two reasons. First, you don't

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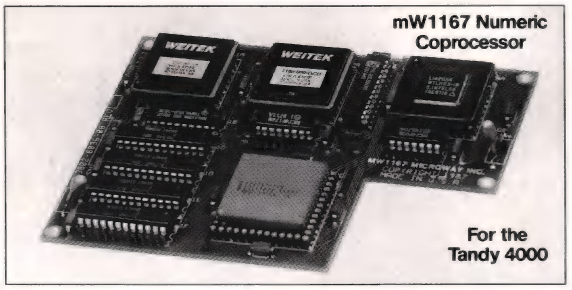

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C CHEST
(continued from page 121)

want myriad date.h files littering all your directories. Second, if you're using a make utility, you only want to recompile the file that *#includes* date.h once a day.

The program's behavior can be modified with the following command-line switches:

-f—forces an update, even if the date stamp is today's.
-v—verbose operation. The program tells you about the current date and so forth as it runs.
-c—forces dateh to create the file if it doesn't already exist.

The source code for dateh is in Listing Two, page 110. It is much more straightforward than calendar.c. Command-line switches are processed on lines 50–65. The *stat()* call on line 69 does two things. It tests for the existence of a file called date.h (*stat* returns –1 if the file doesn't exist), and if the file does indeed exist, it initializes the *stats* structure with the relevant statistics. Here, I'm interested in the last-modified date stamp held in the *st_mtime* field. This field is converted to a *tm* structure by the *localtime()* call on line 79. I do the same thing for today's date and time on line 86. Finally, the two times are compared on line 91. The rest of the subroutine just modifies the date.h file if the date stamps don't match, getting the relevant information from the *tm* structure pointed to by *t*.

Note

1. My shell is described in my book *On Command: Writing a Unix-Like Shell for MS-DOS* (Redwood City, Calif.: M&T Books, 1987).

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(Listings begin on page 108.)

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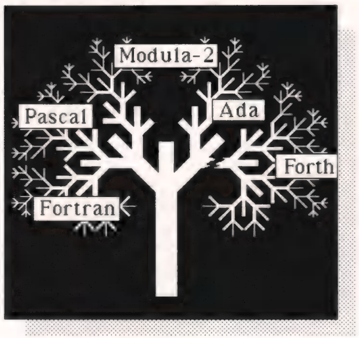

by Namir Clement Shammas

This month I'm going report on some new algorithms for heuristic searching. Heuristic approaches, as you may know, differ from conventional searching by improving their performance over time, by "learning" the characteristics of the data and the requests normally made of it. In this column I'll present algorithms for searching both unsorted and sorted arrays: the methods for searching through unsorted arrays borrow from statistical time-series analysis to create a short-term heuristic memory, whereas the methods for sorted arrays are variations on the traditional index table search scheme.

Unsorted Arrays

The simplest case of a heuristic search involves searching through an unsorted array or list. The search begins with the first array element and examines the rest of the array until a match is found. If the matched element is not the first array member, it is swapped with the previous array element. Thus, the most frequently sought elements tend to bubble toward the front end of the array.

Listing One, page 112, shows a Pascal function that implements a version of the simple heuristic search algorithm. The Pascal function passes an array of data as well as an array of indices. The values of the indices rather than the members of array *Data* are swapped. This approach is more convenient and faster when record structures are used and the search is performed for various keys.

This simple method may be too simple, though. Using it, you may experience any of the following situations, based on the pattern of the data and requests:

1. The statistical probability distribution for seeking any element is uniform. In this case, the benefit of using this method over a simple linear search depends on the actual sequence of sought elements. Thus, the advantage of a heuristic search, at least of this simple kind, is most likely minimal.
2. The statistical probability distribution for seeking array elements strongly favors a particular set of data. Using the simple heuristic method is the most efficient in this situation.
3. There is a shifting trend for seeking different data sets in the array (that is, the statistical probability distribution for seeking any element is also a function of time or call sequence). Here the efficiency of the algorithm is also shifting: after a specific set of data bubbles toward the front of the array, the trend shifts in favor of another set. This causes the members of the new set to bubble toward the front and displace the ones from the previous set. As a result, the efficiency of the algorithm drops to a minimum during a shift in such trends because the sought elements are either in the middle or at the tail.

It is this last case that I want to examine more closely. It is possible to improve the algorithm to take advantage of any patterning of need if you consider the following questions: When do you start searching at the lower array bound? When do you start backward searching at the upper array bound? And when do you start bidirectional searching beginning at the median element?

These three questions have a common solution: you predict the location of the next element from the history of search locations. There exists in statistical time-series analysis a tool to do just this. In the following discussion, I use the weighted average method to provide projections for the next sought location. The equation (which I'll call equation 1) involved is:

$$L[n+1] = (1-f)(L[n] + fL[n-1] + f^2L[n-2] + \ldots)$$

where L[1] . . . L[n] is the array of locations found and f is a fractional factor. L[n] is the location of the last search, L[n–1] is the location of the one before it, and so on. The value of f is usually calculated from the autocorrelation coefficient associated with a given set of values of array L. For the sake of reducing computing time, however, f is assigned a fixed value (say 0.70). As the value of the f factor approaches unity, more weight is given to the "older" data, and vice versa.

With the predicted next location at hand, you can determine the search scheme: first to last, bidirectional to middle, and last to first. This is expressed in the following conditions:

1. If $L[n+1]/(\text{array size}) > 0.65$, then use the last-to-first search scheme.
2. If $L[n+1]/(\text{array size}) < 0.35$, then use the first-to-last search scheme.
3. If $0.35 <= L[n+1]/(\text{array size}) <= 0.65$, then use the bidirectional-middle search scheme.

Listing Two, page 112, shows the Pascal function *Search2*, which employs the modified heuristic method just described. It uses equation 1 with f = 0.70. The last four search location values are used to predict the next search location, and the

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(continued from page 124)

predicted next location is calculated as a fraction of the total number of array elements. This fractional value is then used in selecting the search scheme. Notice that the function updates the search location history only when matches are found.

Ordered Arrays

Conventional (nonheuristic) searching through ordered arrays usually employs index tables. The search for a given datum begins in the index table whose entries define a range to be examined in the array. The sought datum may or may not find its match within that range and is guaranteed not to match outside the range. Normally, the index tables are specified ahead or initialized to set the table entries based on the available data. For an array in which no new members are added and none are removed, the index table remains the same.

This is the basis on which I will now develop and discuss two heuristic search methods for ordered arrays. The basic scheme I use is the dynamic modification of the index table as influenced by the sought data.

In the first of these methods, the index table is constantly changing at run time. It is first initialized by taking evenly spaced elements from the data array. The index table itself is an array with a lower bound of 0. The value of the table entry at the lower bound points to the first element (with common values of 0 or 1) of the data array. The basic algorithm for searching and updating the heuristic index table is:

1. Scan the array elements to compare the search datum with the table entries. Determine the indices to the "first" and "last" members of the data array. Let K be the table index that points to the first member.
2. Search the data array in the range first . . . last.
3. Return the index of the matching element and replace the Kth index table entry with the matching data if a match is found.
4. Return a special coded integer if no match is found.

Listing Three, page 112, shows a Pascal function *Search3* that implements this algorithm and a procedure that initializes the index table.

One of the weaknesses of this heuristic search method is that the index table may contain entries of clustered data. The loss of uniformly distributed or well-spread indices is a major factor in the deterioration of search efficiency. To remedy this clustering problem, I suggest a second method. This new variant combines a few aspects from traditional index tables with the ones in the previous method. The result is a heuristic index table with both fixed and replaceable entries. The index table consists of several sections such that each section begins with one fixed entry followed by m replaceable entries. The algorithm is very similar to that of the previous method:

1. Search the data array in the range first . . . last.
2. If a match is found, return the index of the matching element.
3. If (K–1) is not 0 or a multiple of (m+1), replace the Kth index table entry with the matching data.
4. If no match is found, return a special coded integer.

The test in step 3 protects the fixed entries from being overwritten. This simple modification provides anchor points in the heuristic index table. You can set up the index table using the same method as for the previous search algorithm.

I've discussed all the algorithms I promised, but I can't resist pointing out an interesting variation of the second search method that can be applied to data stored in binary trees. In this variation, a modified index table employs pointers instead of integer indices, with the pointers used to indicate the node at which you start the search in a binary tree rather than taking the traditional approach of starting at its root node. By using the combination of fixed and replaceable pointers in the index table, efficient searching is maintained. Because the fixed array is stored in a binary tree, you can easily construct a balanced or near-balanced binary tree, which adds even more to the efficiency of the search.

If you have developed other heuristic search schemes, I would like to hear from you. Please write to me care of *DDJ*.

Availability

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(Listings begin on page 112.)

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TURBO TECH REPORT | The Independent Newsletter for Turbo Pascal Programmers

Volume 1, No. 1 September/October 1986

Turbo Watch

Editorial by Namir Clement Shammas

Welcome to the premiere issue of Turbo Tech Report; we hope you find it a useful tool and we look forward to your feedback. You can look forward to Turbo Pascal market news; reviews of libraries, utilities, and books; in-depth articles; and source code on disk in every issue.

When the phone rang, I picked it up quickly: details of Borland's just-announced Turbo Pascal for the Macintosh. I asked the obvious questions. Did the implementation take advantage of the Mac user interface? And if it did, what about the vast number of existing Turbo Pascal programs not written with the Mac interface in mind? Did it offer any clues about the nature of the next MS-DOS version? Was it compatible with the Mac Hierarchical File System (HFS)? When would it be released? How much?

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As I keyed in the answers, Paul McCartney was crooning in the background "open the door and let them in." It's true that TPMac will let the Macintosh Pascal programmer in on the world of Turbo Pascal programming, and that's good: the Mac has suffered from the lack of a quick-start software development environment ever since it was released. Even Apple recognized the importance of TPMac and sent chairman John Sculley to the product announcement press conference. The announcement is of importance to the MS-DOS crowd of Turbo programmers as well; they're getting a sneak preview of some features that are sure to be included in the MS-DOS Turbo Pascal Version 4.0.

But the real significance of this product is in what it offers to the Turbo Pascal programming community -- Borland has made it possible for a number of existing Turbo Pascal programs to run without modification market for Turbo Pascal programs and utilities has now expanded to all the major personal computer operating system environments, from CP/M through MS-DOS to the Mac's new HFS.

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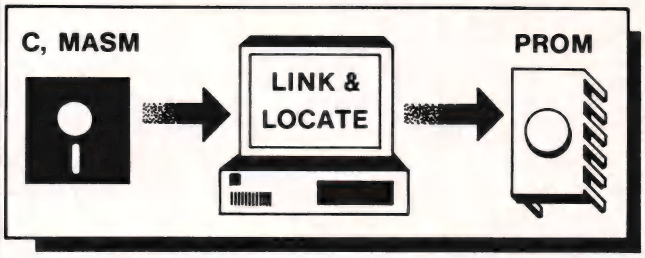

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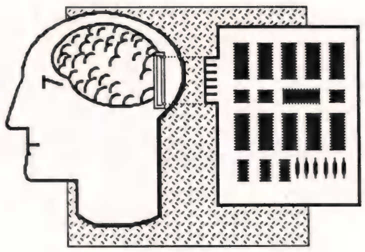

If you've been following this column, you will have noticed a strong emphasis on object-oriented tools. That's because I've been deeply involved in the evaluation of object-oriented technology for the past year or two. I'm not alone: in the course of this evaluation, I've met many professional programmers from both large and small companies who are evaluating or actively using object-oriented systems. Large companies such as Hewlett-Packard and General Motors are using object-oriented approaches in major development work. There is a major thrust going on in the industry just now to introduce this technology into important and even critical projects.

Nevertheless, some programmers and managers are reluctant to adopt object-oriented tools. I thought it would be a good idea to devote some column space this month to some of the reasons why people have, after investigating the paradigm, abandoned or avoided it. Also, if any of you have had the experience of deciding whether to use the object-oriented approach in a major programming project, please write and tell me about your experience. I'm interested both in those in which you chose the object-oriented approach and those in which, after some serious study, you decided against it.

I also discuss this month what object-oriented programming has to offer to artificial intelligence work,

by Ernest R. Tello

and I consider what tools are needed to really exploit the object-oriented paradigm in AI.

Adventures in Object-Oriented Programming

One programmer I spoke with is Al Globus, who works at NASA Ames for the contractor Sterling Software. Al used an object-oriented C tool in a project involving simulating life patterns that might occur on the space station. Recently, Al went back to using straight C. His reasons for switching back intrigued me. But what intrigued me even more is that even though he was using regular C, he was still, in a way, doing object-oriented programming. He had abandoned the tool but not the paradigm.

The point is important and is often overlooked: it is not always necessary to use an object-oriented programming language to program in the object-oriented paradigm. Al admitted that it was primarily because he had already worked on the program in an object-oriented language that he was able to do object-oriented programming in regular C. He had got to know the code and the problem addressed so well after writing the program once that it was not all that difficult to write it again without the aid of an object-oriented programming tool.

I also spoke with Serge Hering, a software engineering consultant who evaluated an object-oriented C package as a candidate for a real-time system in an IBM PC/AT environment but decided against it. Although sympathetic toward the concept of object-oriented systems, Serge doubted that current tools and the industry at large had matured enough for the concepts to be put to use in the project he was undertaking. As he put it, "Object-oriented concepts will have to encompass all aspects of computing systems to be really practical."

According to Serge, a true object-oriented C system needs to be more than just a preprocessor to C. It requires that the object-oriented paradigm be supported at the operating system level (he's concerned with doing multitasking). After calling one of the vendors and questioning the staff on this point, he was told that object-oriented C on an AT was not a suitable vehicle for implementing a multitasking application.

His basic position now is that object-oriented programming is an all-or-nothing affair. In order for it to really work, it will have to be adopted across the industry, or attempts at using it are liable to backfire. The additional overhead required by object-oriented systems, he feels, can be handled in the proper environment, but the danger is that aspects of a system that have not been implemented with the object-oriented approach in view could come back to haunt it unless the paradigm gets the kind of industrywide support he describes.

Personally, I find Serge's view, for all its merits, a bit too conservative. The most interesting point I think he raises is just what an object-oriented C that encompassed more than just a preprocessor to C might look like. I would be interested in hearing from readers who may have an idea on what such a "total" object-oriented system in the C environment might comprise.

Object-Oriented Programming for AI

But I haven't really explained why I am concentrating so much on object-oriented programming in a column ostensibly devoted to artificial intelligence techniques. It's simple, really.

I believe that organizing programs along object-oriented lines is not only one of the best means we have

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TEXAS INSTRUMENTS

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(continued from page 130)

so far for achieving greater programming efficiency and modularity but also that it has important implications for the goals of AI. These potential advantages and implications do not come automatically with the use of the paradigm, but through it many of them seem to be much more attainable. Possibly one of the most important issues is the potential of object-oriented systems for alleviating the problem of "sequential closure" in programming.

What I am referring to by the term *sequential closure* is the fact that, in the current stage of software technology, if part of a program breaks, then very often the whole program breaks. This stands in contrast to most living organisms, which show considerable resiliency or "fault tolerance" to breakdowns in their functioning parts. This phenomenon seems nowhere more prevalent than in the brain. Many studies have shown the astounding degree to which the brain can adjust to massive tissue loss, for example. But, as we know, removing even a line from most programs can be fatal.

As sequential closure is so much a part of current programming technology, it might be useful to spell out why I think it is not the most desirable constraint to have. As I see it, there are three main consequences of the sequential closure of current software technology:

1. A considerable amount of programming time must be spent not only in debugging but also in redebugging.
2. There is an inherent limit to how "user-friendly" programs can be.
3. There is an inherent limitation on the flexibility and generality of problems that programs can address.

Most programmers would agree, I think, that advances are needed to improve the state of our technology in at least one, if not all three of these areas.

Object-oriented programming is not a magic fix for these problems, but there is at least one area in which, I believe, it can help significantly. The main feature of the object-oriented approach that makes this possible is the ability to accomplish a new and important degree of partitioning of large-scale functionality.

Now there is nothing new about partitioning the functionality of the program. Libraries provide this. We currently take for granted the way that reusable library functions can be written so as to be used time and time again in a variety of situations. Of course, this reusability often comes only at the expense of a great deal of effort, but it is taken for granted that it is one of the goals of competent programming.

The problem is that functions are still at a fine-grained level in the organization of most reasonably sized programs. The main sequence of code that calls the library functions is still very much subject to sequential closure. The code consists of a sequence of statements and subroutines that provides a closure on the correct functioning of the program that often must be debugged and redebugged each time important modifications are made to the program. As programs get larger and more complex (as in the case of AI), it becomes imperative that much larger functioning parts

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of programs have this packaged functionality so that they do not have to be repeatedly adjusted and debugged to accommodate changes and additions in other parts of the code.

Object-oriented programming can provide broader-grained partitioning. This is, of course, one of the reasons that suggested to Doug Cox, the author of *Object-Oriented Programming: An Evolutionary Approach* (Addison-Wesley, 1986), that object-oriented systems could be described as software ICs.

In the case of hardware ICs, we have units of packaged functionality that can be used in a wide variety of cases without modification or further debugging. The scope of ordinary library functions is so narrow that no one has suggested that they be compared with ICs. It is only in the most rudimentary programs that functions operate as main operating parts within the program.

Functions are usually at the same time too general and too specific to have this role. They are too general in that, rather than being a functioning part of an actual program, they are more like standard nuts and bolts that come in an enormous variety of sizes. Without any arguments supplied, with many functions it is still often unclear just what they will do.

On the other hand, functions are too specific in that the variety of situations to which they can respond is often very limited. A function usually requires that the programmer know in advance just what situation is being covered each time it is called. Functions are also specific in that the types of things they are responsible for are usually fairly detailed, low-level operations. With objects, which are usually made up of several closely related and interacting functions, we have a way around this limitation.

Consider classes. Classes in the object-oriented paradigm are a kind of IC template for stamping out custom working parts for a wide variety of programs. There may be only a small number of instances of that class that are actually used in a given program. But in making those instances, it is typical to assign values to instance variables that define the conditions of a problem once and for all while still leaving open the issue of just what messages will be sent to what objects at what time. What can be set without hand coding by the programmer, however, is what arguments these methods will take in a lot of cases. It is possible to have a systematic way of assigning whole sets of arguments to methods simply by setting values to instance variables at the time an object that acts as a functioning part of a program is initialized. I hope in a later column to provide some actual coded examples of this.

Inference Engines for Objects

I believe that the object-oriented approach has a lot to contribute to furthering the goals of AI. Using object-oriented systems to model problem domains can be a little deceptive, though, unless some crucial design issues are met. Simply creating a static model of the unique aspects of a certain "world" of activity, such as the world of medical diagnosis or electronic troubleshooting, is no guarantee that programs using such models will be at all intelligent.

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ARTIFICIAL INTELLIGENCE
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just sits there statically, it does not contribute the kind of knowledge we are interested in, no matter how well the world model may have been designed. Everything depends on the techniques used for making use of that information. The more actively a program can be designed so as to be continually accessing the knowledge incorporated in a hierarchical model of a problem space, the more intelligence will have been gained.

In rule-based systems, the inference engine is a general program that accesses knowledge in the form of rules and keeps things moving so that the knowledge captured in rules gets used and applied. But so far, there have not been any general-purpose "inference engines" built for accessing knowledge in the form of objects. As things now stand, we are just beginning to get the idea of how to use these structures in a very ad hoc way. It is worthwhile, though, to speculate a little bit on what generic routines might be important for AI programs using objects to create deep models of domains.

Certainly some unusual, yet generic, search routines specific to object-oriented systems are a necessity. One such basic routine would be a method that built its own list of all the instances of a given class for the purpose of search, then made its own ordering of the names of these objects, and then searched them for specific information by looking up the values of various slots or instance variables. Far more intricate and flexible search routines are possible, too, such as those that can do a more general type of information gathering so as to provide a temporary seach space of only the relevant data needed for a given situation. This idea of programs that can build temporary search spaces dynamically for use in solving problems efficiently is one that has a broad applicability to several different types of AI application.

An interesting use of class hierarchies in AI has been the partitioning of rule-based knowledge into sets of rules that are organized according to a network of situations in a problem space. Here only the tip of the iceberg has been touched so far. There is room for a wide range of approaches to providing flexible problem solving methods based on sophisticated routines for selecting rulesets to apply by rapid initial searches up and down a hierarchy rather than just by executing simple test and branch procedures.

For example, let's say that the application is one of actually building a design for something. Here, one of the important services that computer technology can provide is in helping human designers make sure they have not overlooked anything important. The problem is that what is important in a given design can differ enormously from case to case, depending on the details and requirements of a given design. In such a case it would be useful to have various sets of constraint rules that could be selected and applied in a selective way rather than by a rigid procedure.

One of the key types of know-how that human designers learn by experience is how much detail is relevant for evaluating a given aspect of a design. This is important for avoiding entirely inappropriate analyses and conclusions. So, for example, in some designs, there is enough standardization in the parts being used that an iteration through each part in turn would be absurd. All that is needed is inspection of a few typical elements to reach an important general conclusion. This is the kind of realization that a human designer reaches by common sense but which can be automated. In this case, a general routine could be used that sifted quickly through all the instances of each type of design element used in a proposed design and decided which categories would need a detailed, iterative treatment and which could be evaluated by inspecting typical elements.

The general point that object-oriented systems can be effective for AI applications only to the degree that an active access is provided to the information represented as objects has some interesting consequences. For one thing, it means that an adequate object-oriented programming environment must provide at least some minimum features to make this possible.

First on the list is the ability to keep track of all the objects currently in the system, which includes both classes and instances, according to their place in the hierarchy. That's more powerful than it sounds; part of what we consider simple common sense, which all normally functioning humans have, is a sense of the place of things in an implicit logical or conceptual hierarchy. It's also what conventional programs don't have.

For example, we take it for granted that bicycles and cars are a means of transportation and hence are in the category of equipment or artifacts and that, therefore, certain kinds of behavior with them are appropriate. The boundaries of this are subject to challenge, of course, but we take it for granted that it is not appropriate to use a piano for firewood or to risk our lives to rescue a bookend from a burning house. We know that liquids cannot be safely wrapped in newspaper and millions of other bits of general, practical knowledge that seem to be stored as a general understanding of types of things and their roles and characteristics.

The logical way to represent this common sense knowledge of how to get around in the practical world is as some kind of conceptual hierarchy. That way, the mere fact that a given object is an instance or member of a class will activate certain knowledge about how to deal with objects of that type.

The two main ways this is currrently done in AI are by use of rule-based programming and procedural attachments or active values. In many of the larger professional AI programming systems, it is possible to store rules about classes of things that are invoked for certain types of objects. The problem, though, is to provide a means of determining when it is appropriate for such knowledge to be invoked. Active values or procedural attachments act like "demons" that are waiting for certain events in order to be invoked. So various operations can be waiting in the wings, as it were, for certain values to be changed or accessed.

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So, for example, if we attempt to change the physical state of an artifact, such as by burning a piano, before that operation can be permitted, certain procedures can be automatically invoked that apply knowledge about appropriate behavior for that class of things. A demon for wooden objects might state that things in the category of useful furniture have a greater value than satisfying temporary needs for warmth by destroying them.

When representing knowledge to be used to solve certain problems, you are constantly faced with decisions about how implicit or explicit to make the knowledge. In conventional programming the knowledge that is incorporated in a program is nearly always completely implicit. That is, it does not really exist as knowledge in the program other than as knowledge used by the programmer to design its functioning.

In AI paradigms such as rule-based programming, the attempt is made to make knowledge explicit as general rules so that this knowledge can be applied to new situations not entirely foreseen by the developer. The ability to handle novel situations is still limited, however. So far, the main advantage gained by making knowledge explicit is that greater generality and flexibility can be given to applications. Rather than having the knowledge "hard-wired" into a conventional program that is not capable of comparing different pieces of knowledge to reach its own conclusions, it is useful to provide a way of modeling the general process by which practical results are obtained. The alternative is just using the results in a purely ad hoc way.

Obviously, it is never possible to make everything the result of a process of explicit reasoning. Even humans could not function that way. Nothing would ever get done in real time. We would all end up like parodies of Hamlet, forever analyzing the pros and cons of every aspect of even the most trivial actions. One of the rules of thumb for practical activity, whether by human or machine, is that certain things must be taken for granted as implicit and used for a limited number of events of explicit analysis or reasoning.

From this point of view, we can see one of the main distinguishing features of human as opposed to machine analysis. At any given time, we can decide to change something from the status of implict to explicit if we need to for any reason. It's an important part of living to sense when it is necessary to question things normally taken for granted. So far, with AI systems, the decision about what knowledge will be implicit and what explicit is decided by the programmer and cannot be changed except by rewriting the program. In a future column I will describe a program I have been designing that actually decides to some degree.

So, as things now stand, the main trade-off, as always, is flexibility vs. efficiency. The question is how much knowledge can be made explicit without losing adequate performance. This is always problem specific. For some problems, a week of processing time would be acceptable if the result obtained were accurate and reliable enough. For others, even ten seconds might seem an eternity. Making the proper choice between what to make explicit and implicit in an AI program is often something that can only be done by developers with a great deal of experience in the field. Even here, often decisions made early on turn out to be proven wrong later in the game.

The advantage of modular paradigms such as rule-based and object-oriented systems, though, is that changes can usually made by local modifications that do not alter the functioning of the program as a whole. Often knowledge can be made explicit by adding and subtracting various rules and/or functioning classes that do not require that the application be substantially rewritten. And that sort of functional partitioning is essential to any large-scale programming project and especially to work in artificial intelligence.

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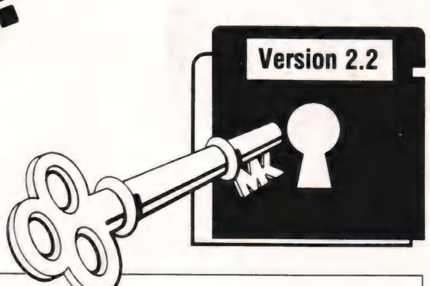

turn this

```
C:>DEBUG PROGRAM.COM
-D100 136
8848:0100  EB 18 49 6E 63 6F 72 72-65 63 74 20 44 4F 53 20   k.Incorrect DOS
8848:0110  76 65 72 73 69 6F 6E 0D-0A 24 50 B4 30 CD 21 86   version..*P40M!.
8848:0120  E0 3D 36 01 72 05 3D 0A-02 76 09 BA 02 01 B4 09   `=6.r.=..v.:..4.
8848:0130  CD 21 CD 20 58 EB 2F                              M!M Xk/
-Q
```

into this!

```
H00100: JMP     Short H0011A                            ;00100 EB18              --
;-----------------------------------------------------
        DB      "Incorrect DOS version"                 ;00102 496E636F727265
        DB      0Dh                                     ;00117
        DB      0Ah                                     ;00118
        DB      "*"                                     ;00119 24
;-----------------------------------------------------
H0011A: PUSH    AX                                      ;0011A 50                P
        MOV     AH,30h                                  ;0011B B430              _0
        INT     21h             ;1-DOS_Ver_Number       ;0011D CD21              _!
        XCHG    AH,AL                                   ;0011F 86E0              __
        CMP     AX,0136h                                ;00121 3D3601            =6_
        JB      H0012B          ; . . . . . . . . . .   ;00124 7205              r_
        CMP     AX,020Ah                                ;00126 3D0A02            =__
        JBE     H00134          ; . . . . . . . . . .   ;00129 7609              v_
H0012B: MOV     DX,0102h                                ;0012B BA0201            ___
        MOV     AH,09h                                  ;0012E B409              __
        INT     21h             ;1-Display_String       ;00130 CD21              _!
        INT     20h             ;TERM_normally:20h      ;00132 CD20              _
;-----------------------------------------------------
H00134: POP     AX                                      ;00134 58                X
        JMP     Short H00166                            ;00135 EB2F              _/
;-----------------------------------------------------


MASTER*KEY XREF - PROGRAM.XRF                                            Page 1

0102h                  :    121   2F5   301   320
020Ah                  :    126
03CBh                  :    12B
1-Display_String       :    130   591   610
1-DOS_Ver_Number       :    11D
H00100                 :    100
H0011A                 :    100   11A
H0012B                 :    124   12B
H00134                 :    129   134
H00166                 :    135
TERM_normally:20h      :    132
```

NOTE: The cross-reference is by memory location within the program file!

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(continued from page 12)

type unevenly, the average typing speed was often much less than ten characters per second.

In spite of their slowness the teletype machines were the most practical terminals for multiuser systems (then called time sharing systems) and for small computers. The electronic terminals using a CRT were at that time dumb terminals and very expensive. Furthermore, if hard copy was desired it was necessary to buy a printer which would cost almost as much as a full teletype terminal. The widespread use of teletype machines as terminals left its mark on computer standards in many ways besides the TTY abbreviation. The most important is probably the ASCII code. This was developed for the teletype machines and then adopted by computers when the teletype machines were adopted as terminals.

Many computerists are puzzled by the fact that all of the control codes except DEL are at the beginning of the codes while DEL is at the very end. The old name for DEL, RUBOUT, gives a clue to this mystery. Because it was very difficult to type at anywhere near the maximum of ten characters per second on the teletype machines most teletypes were equipped with a paper tape punch and reader. The message was punched into paper tape off line and then transmitted at the maximum rate by the tape reader on line to save expensive on line time. But suppose you made a mistake and hit the wrong key near the end of punching a long tape. Once a key was struck there was no way to unpunch the holes in the tape and it would be very frustrating to have to do the whole tape over again. Instead the tape was manually backed up to the error and the error overpunched with the RUBOUT code which punched all the hole positions. The receiving teletype was set to ignore RUBOUT codes so that the errors simply didn't print.

The paper tape units came in at least two version, the 7-bit and the 8-bit types. The 7-bit type was common for most communications uses but for computers and for communication channels with a parity bit the 8-bit units were used. With computers paper tapes were used for off line storage and for distributing software. For computer use at the computer high speed paper tape punches and readers were developed and became so common that CP/M had input/output channels reserved for them.

Many of the earlier and less expensive teletype machines were upper case only and this is one of the reasons that BASIC as developed at Dartmouth College would work with all upper case. Apparently the Bell Labs could afford the more expensive teletypes with the full character set and both C and Unix are case sensitive although Unix has a provision for translating upper case to lower case for upper case only terminals and both tend to use mostly lower case. Some teletypes could transmit either case although they printed upper case only, translating lower case to upper case when receiving.

Note that all of the older text editors such as ed on the Unix system are line editors and that only the newer editors such as vi are full screen editors. That is because with the teletypes as terminals there was no screen.

This is not the first case where decisions made in the past for valid reasons persist in standards long after the reasons for making those decisions no longer apply. After all the gauge of modern railroads was set by decree of an ancient Roman emporor and the layout of the standard typewriter keyboard was made to discourage fast typing and thus avoid key pileups. After a standard has been in use for a while there are many things around embodying that standard that would be obsolete if the standard were changed so old standards linger on long after they are obsolete.

Incidentally the slow teletype machines hooked to a timesharing system seemed like a big advance to programmers who previously had to punch their programs on a card punch and submit them for batch

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Maximum Numeric Array	UNLIMITED	64K	64K
Max. Number of Array Dimensions	255	63	8
Max. Number of Elements/Dimension	UNLIMITED	32K	32K
Dynamic Redimensioning	YES	NO	NO
Matrix I/O Statements	YES	NO	NO
STRING/FILE HANDLING			
Maximum String Length	64K	32K	32K
Total String Space	UNLIMITED	64K	64K
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CIRCLE 344 ON READER SERVICE CARD

(continued from page 138)

processing every time they wanted to try something. Then they would wait hours or even days for the results which might be only a cryptic error message. Think how that would affect your debugging procedures.

David S. Tilton
27 Pennacook St.
Manchester, NH 03104

Interrupts

Dear *DDJ*,

Thomas Zimniewicz wonders (in his article "An Extended IBM PC COM Port Driver," June 1987) why the IBM PC serial ports use a UART bit to enable the interrupt-driver line. They do this so the interrupt can be turned off. Normal computers (Z-80s, etc.) often have such lines driven low by open-collector drivers when signaling an interrupt, so that more than one device can use the physical hardware interrupt wire (the software, in such a case, would be obliged to poll each possible device). Such interrupt lines are "pulled-up" somewhere in the system with a single resistor, so even if nobody is driving the interrupt wire, the CPU won't see erroneous interrupts.

The IBM/Intel hardware, on the other hand, drives the interrupt line high when an interrupt occurs, and the hardware has no inherent mechanism for sharing an interrupt line. The serial cards ameliorate this to some extent by providing a disabling/enabling mechanism attached to a spare bit on the UART; thus, by selectively turning off one guy's interrupt and turning on another, more than one card can use the same interrupt wire; but not really at the same time. The serial cards usually also include a DIP switch enable/disable, which is basically in series with the electrical mechanism.

Here are some of the nice things that can happen if you forget about the interrupt enable bit.

Two or more serial cards—or other cards?—could have their interrupts enabled simultaneously on the interrupt line. This is an electrical short; there probably won't be any smoke or anything, but the interrupts definitely won't work the way

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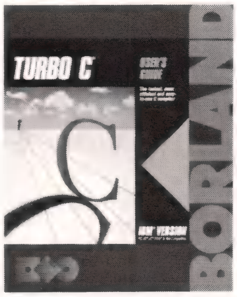

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(continued from page 140)

you expected. You could set-up the interrupt controller properly, but leave the interrupt disabled. According to my *Technical Reference*, this leaves the interrupt line floating, i.e., your interrupts will become phase-of-moon dependent.

Perhaps with PS-17 or whoever, IBM will come up with sophisticated hardware comparable to the average microwave oven controller of today. We can but hope.

J.G. Owen
35 Admiral St.
Port Jefferson Station, NY 11776

Bandwidth Bottleneck

Dear *DDJ*,

I have noted the thoughts on memory and bandwidth in recent issues of *DDJ*; they're forward-looking and pertinent to an issue which is of increasing concern to programmers and hardware designers alike. In particular, the editorial in the March issue got me thinking with the reference to commuting. How many times have I myself sat in my car, creeping along, wishing for "more bandwidth?" Then, as the highway crews build in more bandwidth, more cars come out of the woodwork to clog it all up again.

The central question becomes not how, but why. Why should massive amounts of data be thrown from storage to processor, often in order to locate or operate on a minuscule fraction thereof, and then thrown back again, or even dumped? As long as processing power is located over here and data over there, data volume will always grow to overwhelm the physical channel, similar to budgets and pocketbooks.

Two approaches to this problem seem to point in fruitful directions: more efficient data transfer and eliminating data transfer entirely. The latter is not necessarily the logical extension of the first.

Using current technology and its extrapolations, it seems possible to explore more advanced methods of storing and indexing data so that the patterns inherent in the data are more "visible" to the data user. If the system wishes to use data for inferences or "inference-primitives," rather than as fragments which must be assembled into inferences each time or when data will be transferred, distill it first. The extra processing time up front would greatly reduce operations time later.

Eliminating data transfer, however, would require a more fundamental change in the way data and processor work together. Perhaps we are seeing the beginnings of this quantum leap in the advancing neural-network research. Why must Mohammed go to the mountain? Make Mohammed be the mountain! Data essentially becomes the processor and the problems associated with transfer to and from processing centers disappears. Analog computers operate in this fashion; the construction of the computer is really data to be operated on. The computation is essentially instantaneous without the need to read or otherwise handle data as a separate entity.

I suppose that the issue revolves around the old "chicken-and-the-egg" dilemma. If we can eliminate the need to handle all of the data, perhaps we would know the answer before asking the question, or the solutions might fail to be general enough to be truly useful. Additional research on what data really is will help us find our way.

Thanks for placing such an important issue before the informed and active computing public of *DDJ* readers. I'm sure that there will be much informed comment and discussion.

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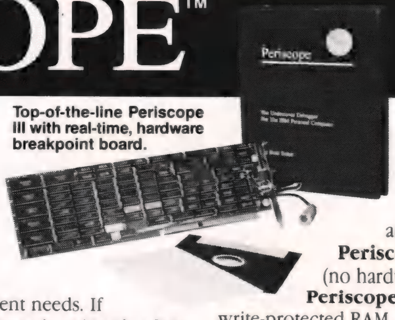

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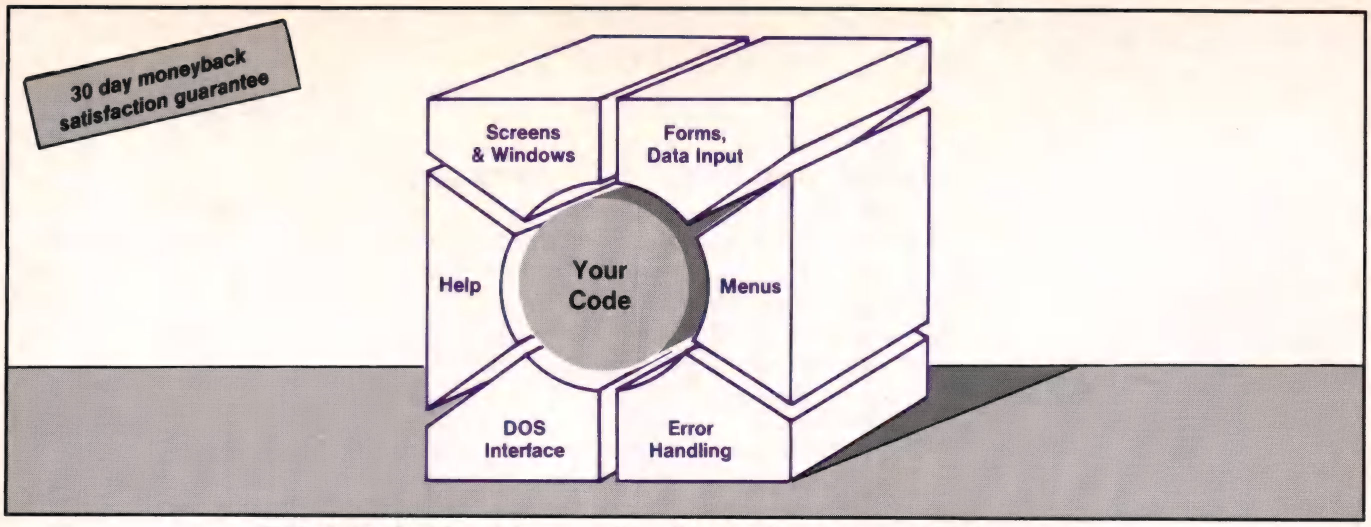

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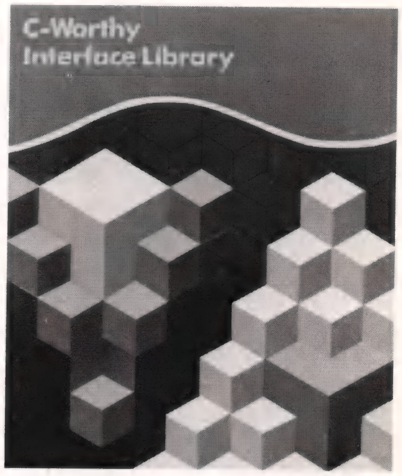

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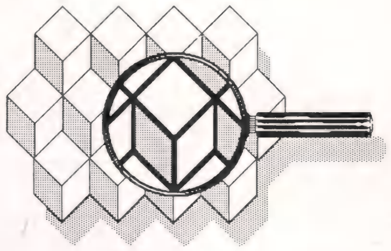

Sigma Designs has announced SigmaVGA, a high-resolution graphics board. As its name implies, SigmaVGA offers compatibility with IBM's new Video Graphics Array (VGA) standard. It also offers compatibility with the IBM monochrome display mode and CGA, EGA, and the Hercules graphics adapter modes, and it supports single-scan and multisync monitors as well as the IBM PS/2 analog color and monochrome monitors. SigmaVGA has 256K of on-board memory and permits up to 256 colors to be selected from a palette of 262,144 colors.

According to Sigma Designs, SigmaVGA supports all the new VGA BIOS mode and function calls, including 320 × 200 in 256 colors or 64 gray scales; 640 × 480 in 16 colors or gray scales; 720 × 400 in 16 colors or gray scales; and simultaneous display of two out of a possible eight character sets stored in memory. It can also save and restore video states for use in multitasking applications and offers 132-column support with all digital monitors.

The SigmaVGA graphics board retails for $499 and comes bundled with Show Partner, Version 3.0, from Brightbill-Roberts & Co. of Syracuse, New York. Show Partner is an application designed to capture screens from any source, then present them using a variety of special effects and animation techniques, including color, motion, and sound. Reader Service No. 16.
Sigma Designs Inc.
46501 Landing Pkwy.
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Video Seven has announced a single-chip EGA that is completely hardware compatible with EGA, CGA, MDA, and HGC (Hercules graphics board) display modes. The chip is contained in a 160-pin package and features a complete implementation of the EGA hardware as well as a fully functional 6845 CRT controller. Advanced features include enhanced automatic switch support, dot clock speeds of up to 34 MHz, double-scan capability, and built-in support logic. The board is manufactured for Video Seven by LSI Logic.

The price has not yet been determined. Reader Service No. 17.
Video-Seven Inc.
46335 Landing Pkwy.
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(415) 656-7800

Graphics Software Systems has released the OS/2 Graphics Development Toolkit for the advance release of OS/2. The OS/2 GDT includes device drivers for VGA, EGA, and CGA graphics adapters; the Microsoft Mouse; the IBM Proprinter, Graphics Printer, and Color Graphics Printer; the Quietwriter III; and plotters from IBM and HP. Additional drivers now under development include IBM/PS/2 Mouse, the HP LaserJet+, and laser and dot-matrix printers from Epson and other vendors.

The OS/2 GDT advance release includes language binding to support Microsoft C and Macro Assembler. The final version of OS/2 GDT will support OS/2 implementations of C, BASIC, FORTRAN, Pascal, and Macro Assembler from IBM and other third-party vendors.

The list price is $995, with discounts available to registered owners of the GSS Graphics Development Toolkit for DOS. A final version of the OS/2 GDT will be available from GSS when the final version of OS/2 is available from Microsoft and IBM. Reader Service No. 18.
Graphics Software Systems Inc.
9590 S.W. Gemini Dr.
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(503) 641-2200

Atron has announced Windows Probe, a set of debugging tools for developers using the Microsoft Windows operating environment. The tools permit trapping programs that are not yet in memory but reside on disk. With many programs operating simultaneously, program bugs have a far greater chance of corrupting other programs as well as themselves. Windows Probe tracks the program in real time and adjusts symbolic and source-level debugging information accordingly.

Atron's AT PROBE contains 1 megabyte of hidden and write-protected memory that stores the Windows Probe debugger software and the symbolic and source-level debugging information without taking memory space in the lower 1 megabyte of system memory. AT PROBE's real-time trace feature lets programmers see how the program operated in real time.

Windows Probe is compatible with the C compiler that is part of the Windows development system. Programmers can display and change local and complex data variables as well as do source-level debugging.

Windows Probe costs $495. Reader Service No. 19.
Atron
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Foresight Resources Corp. has recently released a version of its drafix 1 computer-aided design and drafting program for the Atari ST. Drafix 1/Atari ST is the first professional-quality CAD program available for the Atari 520ST and 1040ST computers. The program is menu-driven with available commands displayed. It includes object drawing and editing, snap grid and object snap drawing aids, multiple fonts, crosshatching, an automatic dimensioning system, and symbol library management.

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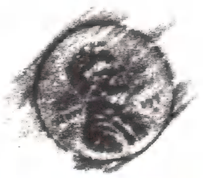

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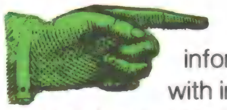

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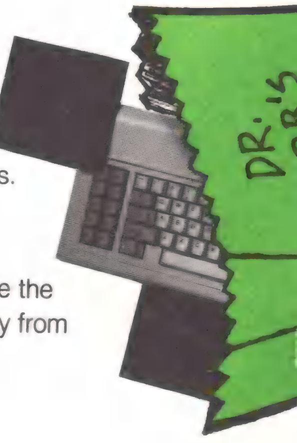

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Raster Technologies has introduced two products in a line of GX4000 parallel-processing graphics accelerators for use with Sun Microsystems' workstations. Raster's GX4330 and GX4340 plug directly into a Sun-3 or Sun-4 VME backplane. They use a new parallel architecture that Raster has developed to execute the proposed ANSI PHIGS and PHIGS+ standards at the fastest possible rate.

The systems offer a 24-bit, true-color display and the ability to create and edit a standards-based 3-D display list structure. They support Sun's X.11/NeWS Window System and 200,000 to 1,000,000 transformed and drawn 32-bit floating-point 3-D vectors per second. The architecture consists of a dual-ported Display List Module incorporating 1-megabit, static column RAM chips.

Reader Service No. 21.
Raster Technologies Inc.
Two Robbins Rd.
Westford, MA 01886
(617) 692-7900

MacMemory has released Turbo SE, a 16-MHz 68000-based accelerator board for the Apple Macintosh SE that offers a minimum speed increase of 200 percent. Users also have the option of moving the Macintosh SE ROMs to the Turbo SE board to double the speed of all ROM operations. This increase is 100 percent compatible with existing Mac applications.

Turbo SE sells for $599. Reader Service No. 22.
MacMemory Inc.
2480 N. First St.
San Jose, CA 95131
(408) 922-0140

AJS Publishing has released db/LIB, a database library that features a set of 20 assembly-language procedures that give Microsoft's QuickBASIC (Version 2.0 or later) full relational database management capability and dBASE III standard file compatibility for database, index, and text files.

In addition to the library files, the db/LIB software package contains several executable data management routines, including Browse, Copy Structure, and List. Features include the ability to search and index on memo fields, offer direct access to the keys in index files and to the database file header, and provide access to files down any subdirectory path.

The db/LIB software internally manages its own system of record buffering and, by writing records to memory buffers rather than to disk, makes many applications run appreciably faster. It employs dynamic string allocation for user variables returned by the library, which means that variables do not require preallocation of string space.

Db/LIB sells for $139. Reader Service No. 23.
AJS Publishing
P.O. Box 379
North Hollywood, CA 91603
(818) 985-3383

Sterling Castle Software has just released Version 4.0 of the BlackStar C Function Library. The new version

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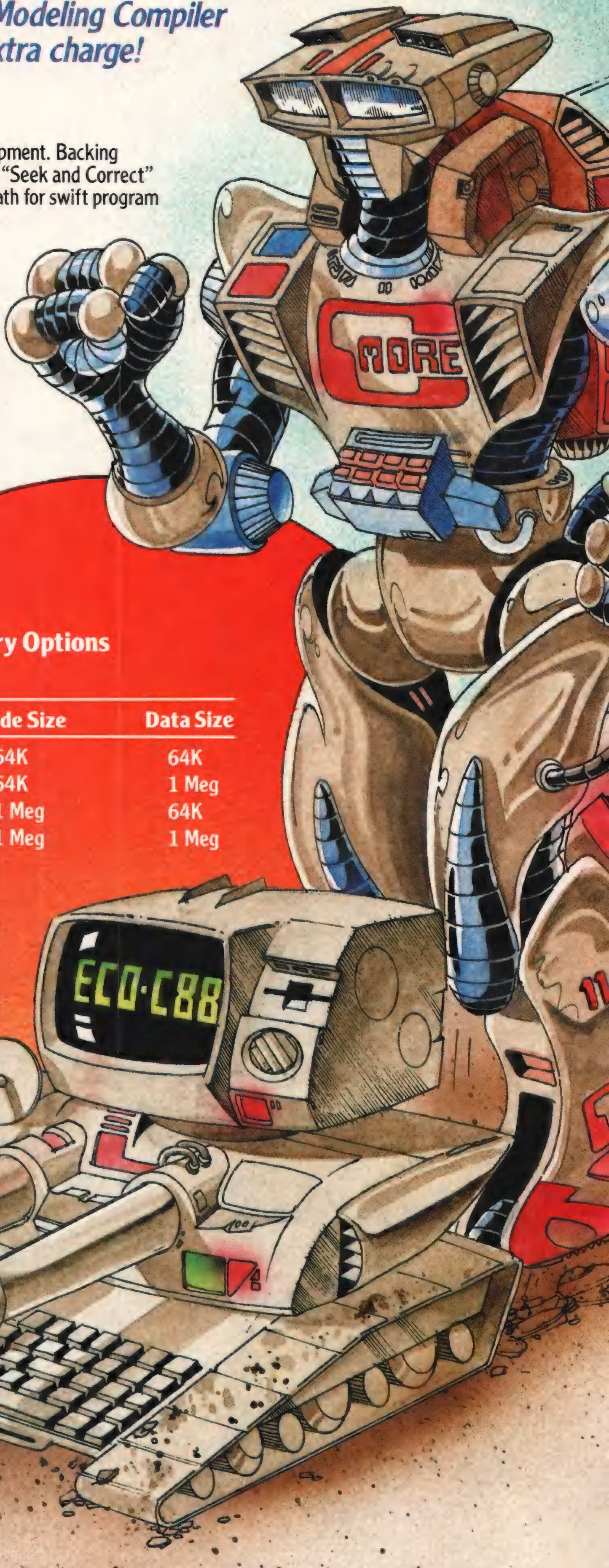

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You already know that fast compilation does not mean fast program development. Backing up for bogus error messages and removing the bugs takes time. Eco-C88's "Seek and Correct" three - way error checking finds even the most elusive bugs, clearing the path for swift program development.

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Ecosoft Inc.
6413 N. College Ave.
Indianapolis, IN 46220

(317) 255-6476 (Tech Info)
(800) 952-0472 (Orders)

(continued from page 146)

supports the EGA, allows terminate-and-stay-resident program development, and has six new serial communication functions. The TSR function enables the development of programs that can pop up and be utilized while another program is running. The library supports the standard ANSI language; is compatible with Microsoft C, Version 3.0/4.0, and Lattice C, Version 3.0; and is adaptable to other versions.

The product offers more than 300 functions, including device handlers for screen, graphics, keyboard, printer, and mouse. It also has the capabilities of interrupts, string, menu, date, time, and system functions and uses primitive functions written in assembly language to improve speed and memory usage. The library includes complete source code and small-, medium-, and large-memory models.

Version 4.0 costs $129. Reader Service No. 24.
Sterling Castle Software
702 Washington St., Ste. 174
Marina del Rey, CA 90292
(213) 306-3020

Silicon Beach Software has introduced Super 3D for the Macintosh, a product that offers 3-D graphics modeling and animation for professional engineering and graphics arts applications. It was designed to provide artists, architects, engineers with dynamic simulation and modeling capabilities.

Modeling tools allow users to create shaded shapes in more than 16,000 colors, 3-D animation for dynamic visualization of complex structures, and movie-camera-like tools for precise visual control. The tool palette offers ten basic tools for creating graphics primitives such as points, lines, arcs, circles, ovals, rectangles and polygons. Objects can revolve about any axis or they can be extruded, translated, scaled, flipped, replicated, and mirrored or arbitarily reshaped.

Super 3D is priced at $295. Reader Service No. 25.
Silicon Beach Software Inc.
P.O. Box 261430
San Diego, CA 92126
(619) 695-6956

NeXT and Adobe Systems Inc. have announced a jointly developed version of PostScript for workstation displays. The new product, Display PostScript, will be independent of windowing systems and include full support for outline fonts, arbitrary line-widths, rotation, and color.

According to Steve Jobs, "Display Postscript allows us to achieve true WYSIWYG from the display to the printed page since the same imaging model is now used for both."

No price has been announced because the product is still under development. Adobe has scheduled a demonstration of the product for the summer of 1988. Circle Reader Service No. 26.
NeXT, Inc.
3475 Deer Creek Road
Palo Alto, CA 94304
(415) 424-0200

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Requires 48K memory. Version 1.2.

Meridian Software
AdaVantage Compiler 2.0
List $795 Ours $735

The Meridian AdaVantage Compiler is a fully validated implementation of the Ada language. The compiler generates native 8086 code in the Intel standard object format. A linker is provided to create stand-alone executable files for MS-DOS. The Meridian AdaVantage Compiler package includes the compiler, linker, library management tools, support packages, runtime libraries and a configuration tool. In addition to the standard Ada packages, support packages are provided to make integer, floating point and text I/O more convenient to implement. The compiler also provides a pragma INTERFACE used to make calls to subprograms written in 8086 assembly language, Meridian C or Meridian Pascal. A source level debugger will be available in late 1987.

Requires hard disk and 640K memory. Runtime fees apply if more than 99 copies are sold. Version 2.0.

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basic language

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db/Lib for QuickBASIC by AJS Publishing	139	119
Finally by Komputerwerk	99	85
MACH 2 by Micro Help	69	55
Microsoft QuickBASIC	99	63
QBase Relational Database by Crescent	89	79
Quick-Tools by BCSoft	130	109
QuickPak by Crescent Software	69	59
Scientific Subroutine Library by Peerless	125	99
Screen Sculptor by Software Bottling	125	91
Stay-Res by MicroHelp	69	55
True Basic w/Run-time Special Price	200	99
True Basic	100	79
Run-time Module	100	79
Various Utilities	50	41
Turbo BASIC Compiler by Borland Intl	100	64

blaise products

	List	Ours
ASYNCH MANAGER Specify C or Pascal	175	135
C TOOLS PLUS/5.0 New Version	129	99
KeyPlayer Super Batch Program New	50	45
LIGHT TOOLS for Datalight C	100	65
PASCAL TOOLS	125	95
PASCAL TOOLS 2	100	79
PASCAL TOOLS & TOOLS 2	175	135
RUNOFF Text Formatter	50	45
TURBO ASYNCH PLUS	100	79
TURBO C TOOLS	129	99
TURBO POWER TOOLS PLUS	100	79
VIEW MANAGER Specify C or Pascal	275	199

borland products

	List	Ours
EUREKA Equation Solver	167	105
Reflex: The Analyst	150	99
Sidekick	85	57
Superkey	100	64
Turbo Basic Compiler	100	64
Turbo Basic Database Toolbox	100	64
Turbo Basic Editor Toolbox	100	64
Turbo Basic Telecom Toolbox	100	64
Turbo C Compiler (Call for support products)	100	64
Turbo Lightning and Word Wizard	150	94
Turbo Lightning	100	64
Turbo Lightning Word Wizard	70	47
Turbo Pascal and Tutor New Version	CALL	CALL
Turbo Pascal New Version	100	64
Turbo Pascal Tutor New Version	70	41
Turbo Pascal Database Toolbox New Version	100	64
Turbo Pascal Editor Toolbox New Version	100	64
Turbo Pascal Gameworks Toolbox New Version	100	64
Turbo Pascal Graphix Toolbox New Version	100	64
Turbo Pascal Numerical Methods Toolbox New	100	64
Turbo Prolog Compiler	100	64
Turbo Prolog Toolbox	100	64

c compilers

	List	Ours
C86PLUS by Computer Innovations	497	359
DeSmet C w/Debugger & Large case	209	184
DeSmet C w/Debugger only	159	138
Eco-C Complete System by Ecosoft	140	119
Instant C by Rational Systems	495	369
Instant-C/16M by Rational Systems New	895	695
Lattice C Compiler vers. 3.2 from Lattice	500	265
Mark Williams Let's C w/csd	75	54
Microsoft C Compiler w/CodeView New Version	450	269
Microsoft QuickC Compiler New	99	63
Optimum-C by Datalight	139	95
Turbo C Compiler by Borland	100	64
Uniware 68000/10/20 Cross Compiler by SDS	995	829

c interpreters

	List	Ours
C-terp by Gimpel, Specify compiler	298	219
C Trainer with Book by Catalytix	122	87
Introducing C by Computer Innovations	125	99
Run/C by Age of Reason	120	69
Run/C Professional by Age of Reason	250	145

c utilities

	List	Ours
Blackstar C Library by Sterling Castle New	125	98
C++ by Guidelines w/version 1.1 kernel	195	172
c-tree & r-tree Combo by FairCom	650	519
c-tree ISAM File Manager	395	315
r-tree Report Generator	295	239
Csharp Realtime Toolkit by Systems Guild	600	489
Curses Window Dev Pkg by Aspen Scientific New	119	105
with Source Code	289	249
dBx dBASE to C Translator by Desktop AI	350	299
with Source Code	550	419
Flash-up Windows by Software Bottling	90	78
GraphiC Color version by Sci Endeavors	350	274
GRAFLIB by Sutrasoft	175	159
HALO Graphics by Media Cybernetics	300	205
HALO Development Pkg for Microsoft	595	389
The HAMMER by OES Systems	195	129
PANEL Forms Management by Roundhill	295	215
PANEL/TC for Turbo C by Roundhill	129	95
PANEL Plus by Roundhill	495	395
PC Lint by Gimpel Software	139	99
PLOTHP by Sutrasoft	175	159
RTC PLUS Fortran to C by Cobalt Blue	450	399
Sapiens V8 Virtual Memory Manager New	300	265
Scientific Subroutine Library by Peerless	175	135
TE Text Editor source by Sub Systems	95	85
Vitamin C by Creative Programming	225	149
VC Screen Forms Designer	100	79
Zview by Data Mgmt Consultants	245	139

cobol language

	List	Ours
COBOLspII by Flexus	395	329
FPLIB for Realia COBOL by BCSoft	149	129
Micro Focus COBOL See Micro Focus Section		
Microsoft COBOL See Microsoft Section		
PCDT by Pro-Code	995	895
Realia COBOL with RealMENU	1145	899
Realia COBOL	995	783
RealCICS	995	783
RM/COBOL by Ryan-McFarland	950	639
RM/COBOL 85 by Ryan-McFarland	1250	895
RM/NET+5 by Ryan-McFarland New	300	259
RM/Screens New	395	334
SCREENIO by Norcom	400	379
screenplay for COBOL by Flexus	175	129

css products

	List	Ours
Combo Package by Custom Software Systems	199	175
PC/SPELL Spelling Checker	49	45
PC/TOOLS UNIX-like Utilities	49	45
PC/VI vi Editor	149	99

debuggers & profilers

	List	Ours
386 DEBUG Cross Debugger by Phar Lap	195	129
Advanced Trace-86 by Morgan Computing	175	115
Codesmith-86 by Visual Age	145	98
DSD87 by Soft Advances	125	79
MiniProbe by Atron	395	369
Periscope I with Board by Periscope	345	275
Periscope II with NMI Breakout Switch	175	139
Periscope II-X Software only	145	105
Periscope III 8 MHz version	995	795
Periscope III 10 MHz version	1095	875
The PROFILER with Source Code by DWB	125	89
TURBOsmith Source debugger for Turbo Pascal	99	89
The WATCHER Profiler by Stony Brook	60	51

disk utilities

	List	Ours
Back-It by Gazelle Systems New Version	130	115
Disk Optimizer by Softlogic Systems	60	55
Disk Technician by Prime Solutions New	100	89
FASTBACK by 5th Generation Systems	179	129
Vcache by Golden Bow Systems	50	47
Vopt by Golden Bow Systems	50	47
Vfeature by Golden Bow Systems	80	74
Vfeature Deluxe by Golden Bow Systems	120	111
XenoCopy-PC by XenoSoft	80	69

dos utilities

	List	Ours
Advanced Norton Utilities	150	99
Command Plus by ESP Software	80	69
Desqview from Quarterdeck	100	85
FANSI-CONSOLE by Hersey Micro	75	62
Mace Utilities Paul Mace Software New	99	89
MicroHelp Utility by MicroHelp	59	49
Norton Commander by Peter Norton	75	55
Norton Utilities by Peter Norton	100	59
OPAL Shell Language by Software Factory	99	89
Q-DOS II by Gazelle Systems	70	59
Taskview by Sunny Hill Software	80	55

essential products

	List	Ours
C Utility Library	185	119
Essential Comm Library with Debugger	250	189
Essential Comm Library Software Only	185	125
Breakout Debugger Only Any language	125	89
Essential Graphics	250	183

forth language

	List	Ours
CFORTH Native Code Compiler by LMI	300	229
FORTH/83 Metacompiler Specify Target	750	599
PC/FORTH by Laboratory Microsystems	150	109
PC/FORTH+ by Laboratory Microsystems	250	199
Programmer's Package #1 by LMI New	250	199
Programmer's Package #2 by LMI New	350	279
Programmer's Package #3 by LMI New	500	399
UR/FORTH Also Available for OS/2 by LMI	350	279
UR/FORTH Libraries	500	395

fortran language

	List	Ours
50 MORE: FORTRAN by Peerless Scientific	125	95
ACS Time Series by Alpha Computer Service	495	389
AUTOMATED PROGRAMMER by KGK Automated	995	949
Essential Graphics by Essential Software	250	183
Forlib-Plus by Alpha Computer Service	70	44
FORTLIB by Sutrasoft	125	109
FORTRAN Addendum by Impulse Engr	95	85
FORTRAN Addenda by Impulse Engr	165	138
GRAFLIB by Sutrasoft	175	159
HALO Graphics by Media Cybernetics	300	205
I/O PRO w/No Limit Library by MEF	250	219
Microcompatibles Combo Package	240	215
Grafmatic	135	117
Plotmatic	135	117
Microsoft FORTRAN w/CodeView	450	269
No Limit Library by MEF Environmental	129	109
Numerical Analyst by MAGUS	295	249
PANEL by Roundhill Computer Systems	295	215
PLOTHP by Sutrasoft	175	159
RM/FORTRAN by Ryan-McFarland New Version	599	399
RTC PLUS Fortran to C by Cobalt Blue	450	399
Scientific Subroutine Lib by Peerless	175	135
Statistician by Alpha Computer Service	295	235
STATLIB.GL: by Peerless	295	239
STATLIB.TSF: by Peerless	295	239
Strings & Things by Alpha Computer Service	70	45

greenleaf products

	List	Ours
Greenleaf C Sampler for Turbo C & QuickC New	95	69
Greenleaf Comm Library	185	125
Greenleaf Data Windows Library	225	155
with Source Code	395	249
Greenleaf Functions	185	125

help utilities

	List	Ours
HELP/Control by MDS	125	99
On-line Help from Opt-Tech	149	99
SoftScreen/HELP by Dialectic Systems	195	149

lattice products

	List	Ours
Lattice C Compiler ver 3.2 from Lattice	500	265
with Library Source Code	900	495
C Cross Reference Generator	50	37
with Source Code	200	139
C-Food Smorgasbord Function Library	150	95
with Source Code	300	179
C-Sprite Source Level Debugger Special Offer	175	CALL
Curses Screen Manager	125	85
with Source Code	250	169
dBC III	250	169
with Source Code	500	356
dBC III Plus	750	594
with Source Code	1500	1184
LMK Make Facility	195	138
RPG II Combo All three items below	1100	875
RPG II Compiler No Royalties	750	625
SEU Source Entry Utility	250	199
Sort/Merge	250	199
Screen Design Aid Utility for RPG II	350	309
SecretDisk II Encryption Utility New	120	88
SideTalk Resident Communications	120	88
SSP/PC Scientific Subroutine Library	350	269
Text Management Utilities	120	88

metagraphics products

	List	Ours
LightWINDOW/C for Datalight C	95	79
FontWINDOW	95	79
FontWINDOW/PLUS	275	229
MetaWINDOW No Royalties	195	159
MetaWINDOW/PLUS	275	229
TurboWINDOW/C for Turbo C	95	79
TurboWINDOW/Pascal for Turbo Pascal	95	79

micro focus products

	List	Ours
Micro Focus COBOL/2	900	729
Micro Focus Level II COBOL w/Animator	495	395
Level II COBOL	349	279
Level II Animator	195	155
Micro Focus Level II COBOL/ET for UNIX	CALL	CALL
Micro Focus PC-CICS New	1495	1189
with Micro/SPF New	1595	1269
Micro Focus Personal COBOL	149	119
Micro Focus Professional COBOL	2000	1595
Micro Focus VS COBOL/XENIX	1495	1195
Micro Focus Support Products:		
COBOL/IQ Ad hoc Report Writer	495	395
COBOL/IQ for DOS 3.X Networks	995	795
FORMS-2	295	235
SOURCEWRITER	995	795

microport products

386 Unlimited License Kit	249	209
AT Unlimited License Kit	249	209
DOSMerge286 *Run DOS and UNIX together*	149	129
DOSMerge386 *Run DOS and UNIX together*	CALL	CALL
System V/386 Combination	799	699
386 Runtime System	199	169
386 Software Development System	499	429
Text Preparation System	199	169
System V/AT Combination	549	465
AT Runtime System	199	169
AT Software Development System	249	209
Text Preparation System	199	169

microsoft products

Microsoft BASIC Compiler *for XENIX*	695	419
Microsoft BASIC Interpreter *for XENIX*	350	209
Microsoft C Compiler *w/CodeView* .... *New Version*	450	269
Microsoft COBOL Compiler *with COBOL Tools*	700	429
for XENIX	995	609
Microsoft FORTRAN *Optimizing Compiler/CodeView*	450	269
Microsoft FORTRAN *for XENIX*	695	419
Microsoft Learning DOS	50	36
Microsoft MACH 10 *with Mouse & Windows*	549	369
Microsoft MACH 10 *Board only*	399	279
Microsoft Macro Assembler .... *New Version*	150	93
Microsoft Mouse *for IBM PS/2*	CALL	CALL
Microsoft Mouse *Bus Version*	CALL	CALL
Microsoft Mouse *Serial Version*	CALL	CALL
Microsoft Pascal Compiler	300	179
for XENIX	695	419
Microsoft QuickBASIC	99	63
Microsoft QuickC .... *New*	99	63
Microsoft Windows	99	63
Microsoft Windows Development Kit	500	299
Microsoft Word .... *New Version*	450	269

mks products

MKS AWK .... *New*	75	65
MKS RCS *Revision Control System* .... *New*	189	155
MKS Toolkit *with MKS VI Editor*	139	109
MKS Trilogy *with AWK, CRYPT & Korn Shell* ... *New*	119	99
MKS VI *Editor by MKS* .... *New*	75	65

modula-2 language

LOGITECH Modula-2 Development System .... *New*	249	199
Modula-2 Compiler Pack .... *New*	99	79
Modula-2 Toolkit .... *New*	169	139
LOGITECH Modula-2 ROM Pkg	299	239
LOGITECH Modula-2 Window Pkg	49	39
Macro2 *Macro preprocessor by PMI*	89	79
ModBase *by PMI*	89	79
ModGraph *by TEQNA* .... *New*	50	45
Repertoire *by PMI*	89	75
Science & Engrg Tools *by Quinn-Curtis*	75	67
Universal Graphics Library *by Quinn-Curtis*	130	119

mouse products

LOGIMOUSE BUS *with PLUS Pkg by LOGITECH*	119	98
with PLUS & PC Paintbrush	149	119
with PLUS & CAD Software	189	153
with PLUS & CAD & Paint	219	179
with First Publisher .... *New*	CALL	CALL
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with PLUS & CAD & Paint	219	179
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Microsoft Mouse *See Microsoft Section*		

other languages

ACTOR *by Whitewater Group* .... *New Version*	495	419
CCS MUMPS *Single-User by MGlobal*	60	50
CCS MUMPS *Single-User Multi-Tasking*	150	129
CCS MUMPS *Multi-User*	450	359
Marshal Pascal *by Marshal Language Systems*	189	165
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other products

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Dan Bricklin's Demo Pgm *by Software Garden*	75	57
Dan Bricklin's Demo Tutorial	50	45
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Printer Drivers .... *New*	CALL	CALL
Net-Tools *by BCSoft*	149	129
Norton Guides *Specify Language* .... *New*	100	75
OPT-Tech Sort *by Opt-Tech Data Proc*	149	99
PC/TOOLS *by Custom Software*	49	45
Screen Machine *by MicroHelp*	79	59
SuperSort *by LifeStyle* .... *New*	139	119

phoenix products

Pasm86 *Macro Assembler version 2.0*	195	108
Pdisk *Hard Disk & Backup Utility*	145	99
Pfantasy Pac *Phoenix Combo*	995	595
Pfinish *Execution Profiler*	395	209
Pfix86plus *Symbolic Debugger*	395	209
PforCe *Specify C Compiler*	395	209
PforCe++ *Specify C Compiler and C++*	395	209
Plink86plus *Overlay Linker*	495	275
Pmaker *Make Utility*	125	78
Pmate *Macro Text Editor*	195	108
Pre-C *Lint Utility*	295	154
Ptel *Binary File Transfer Program*	195	108

polytron products

PolyBoost *Software Accelerator* ..... *Special Price*	80	54
PolyDesk III	99	72
PolyDesk III Archivist	50	42
PolyDesk III Cryptographer	50	42
PolyDesk III Talk	70	52
PolyLibrarian *Library Manager*	99	89
PolyLibrarian II *Library Manager*	149	129
PolyMake *UNIX-like Make Facility*	149	129
PolyShell .... *Special Price*	149	105
Polytron C Beautifier	50	45
PolyXREF *Complete Cross Ref Utility*	219	185
PolyXREF *One language only*	129	109
PVCS Corporate *Version Control System*	395	329
PVCS Personal	149	129

program mgmt utilities

Interactive EASYFLOW *by Haventree* .. *New Version*	150	125
PrintQ *by Software Directions*	89	84
Quilt Computing Combo Package	250	199
QMake *Program Rebuild Utility*	99	79
SRMS *Software Revision Mgmt System*	185	159
Sapiens MAKE & V8 .... *New*	439	379
Sapiens MAKE .... *New*	179	155
Source Print *by Aldebaran Labs*	97	75
TLIB *Version Control System by Burton*	100	89
Tree Diagrammer *by Aldebaran Labs*	77	67

raima products

dbQUERY *Single-User Query Utility*	195	129
Single-User with Source Code	495	389
Multi-User	495	389
Multi-User with Source Code	990	699
dbVISTA *Single-User DBMS*	195	129
Single-User with Source Code	495	389
Multi-User	495	389
Multi-User with Source Code	990	699

sco products

Complete XENIX System V *by SCO*	1295	994
Development System	595	499
Operating System *Specify XT or AT*	595	499
Text Processing Package	195	144
Lyrix *by SCO*	595	449
SCO Professional *1-2-3 Workalike for XENIX*	795	595
SCO XENIX-NET	595	495
XENIX System V 386 *by SCO* .... *New*	CALL	CALL

softcraft products

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Xtrieve *Query Utility*	245	184
Report Option *for Xtrieve*	145	99
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Xtrieve/N	595	454
Report Option/N *for Xtrieve/N*	345	269

text editors

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Brief	195	CALL
dBrief *Customizes Brief for dBASE III*	95	CALL
de *by David Livshin* .... *New*	75	65
Epsilon *Emacs-like editor by Lugaru*	195	147
KEDIT *by Mansfield Software*	125	98
Micro/SPF *by PHASER SYSTEMS*	175	139
Microsoft Word .... *New Version*	450	269
PC/VI *by Custom Software Systems*	149	99
SPF/PC *by Command Technology Corp*	CALL	CALL
Vedit Plus *by CompuView*	185	128

turbo pascal utilities

ALICE *Interpreter by Software Channels*	95	66
DOS/BIOS & Mouse Tools *by Quinn-Curtis*	75	67
Flash-up Windows *by Software Bottling*	90	78
MACH 2 *for Turbo Pascal by Micro Help*	69	55
MetraByte D/A Tools *by Quinn-Curtis*	100	89
Science & Engrg Tools *by Quinn-Curtis*	75	67
Screen Sculptor *by Software Bottling*	125	91
Speed Screen *by Software Bottling*	35	32
System Builder *by Royal American* .... *New Version*	150	129
IMPEX *Query Utility*	100	89
Report Builder .... *New Version*	130	115
TDebugPLUS *by TurboPower Software*	60	49
Tmark *by Tangent Designs*	80	69
Turbo EXTENDER *by TurboPower Software*	85	64
Turbo OPTIMIZER *by TurboPower*	75	65
with Source Code	125	98
Turbo Professional *by Sunny Hill*	70	45
TurboHALO *from IMSI*	129	98
TurboPower Utilities *by TurboPower*	95	78
TurboRef *by Gracon Services*	50	35
TURBOsmith *Source Debugger by Visual Age*	99	89
Universal Graphics Library *by Quinn-Curtis*	130	119

wendin products

Operating System Toolbox	99	79
PCNX *Operating system*	99	79
PCVMS *Similar to VAX/VMS*	99	79
Wendin-DOS *Multitasking DOS*	99	85
Wendin-DOS Application Developer's Kit ..... *New*	99	85
XTC *Text Editor w/Pascal source*	99	75

xenix/unix products

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C-terp *by Gimpel, Specify compiler*	498	379
c-tree *ISAM Mgr by FairCom*	395	315
dBx *with Library Source by Desktop AI*	550	419
DIRECTORY SHELL 286 *by American Mgmt Sys* .... *New*	349	295
DIRECTORY SHELL 386 *by American Mgmt Sys* .... *New*	495	415
DOSIX *Console Version by Data Basics*	400	349
DOSIX *User Version by Data Basics*	200	179
Micro Focus Products *See Micro Focus Section*		
Microport Products *See Microport Section*		
Microsoft Products *See Microsoft Section*		
PANEL Plus *by Roundhill Computer Systems*	795	535
REAL-TOOLS *Binary Version by PCT*	99	89
Library Source Version	599	539
Complete Source Version	999	729
RM/COBOL *by Ryan-McFarland*	1250	949
RM/FORTRAN *by Ryan-McFarland*	750	549
SCO Products *See SCO Section*		

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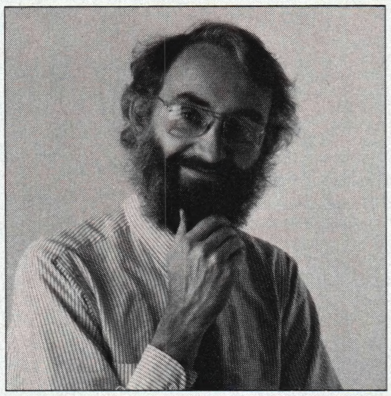

What do the following have in common: binary addition, subtraction, multiplication, and division; sorting; graph connectivity; multiplication of matrices and finding their inverses, determinants, and ranks; polynomial greatest common denominators; and context-free languages?

Answer: they all belong to a class of problems denoted as NC, short for Nick's class, after one Nicholas Pippenger who gave the class formal definition some eight years ago in a paper called "On Simultaneous Resource Bounds" in the *Proceedings of the 20th IEEE Symposium on the Foundations of Computer Science* (IEEE Computer Society, Los Angeles 1979). The problems that gain admittance to Nick's class are just those problems that can be solved substantially faster and more efficiently using many processors rather than one. They are the problems that will drive the growth and spread of parallel processing technology.

Progress on parallel processing architectures seems to be gaining momentum. Some of the approaches include investigating problems such as the Byzantine Generals problem, in which processors have to reach an agreement through message passing even though some of the messages are unreliable, and research on message passing in a sparse network of processors. And up in the hills behind the Berkeley campus of the University of California, researchers at the Mathematical Sciences Research Institute, the "Camelot of complexity theory," have developed significant new parallel algorithms in recent years.

The Fundamental Algorist, Donald Knuth, tells of a visit to the University of Chicago some years ago. Entering a certain building, he encountered two signs. One said "Information Science" and had an arrow pointing to the right; the other said "Information" and pointed to the left. A real-life cartoon of the schism between science and practice, or, as Knuth sees it, between science and art.

Knuth has argued for years that computer programming should be viewed more as an art and that the toolmakers ought to make tools that are a pleasure to use. Floating-point arithmetic should satisfy simple mathematical laws, he argues; then using it for serious purposes could be pleasant. He even thinks that JCL can be beautiful.

Beauty is in the eye of the beholder. Is reverse Polish notation beautiful? How about those Unix program names? Awk! To some, beauty can be structural elegance, as in Bach's "Tocatta and Fugue in D Minor"; to others, it's a clever hack, like Tom Lehrer's "Poisoning Pigeons in the Park."

Alan Turing, one of programming's patriarchs, loved a clever hack. Turing, as his colleague James Wilkinson put it, "was particularly fond of little programming tricks (some would say he was too fond of them to be a 'good' programmer)." Because the world's first working program on an electronic stored-program computer ran on June 21, 1948, and Turing was writing programs for the machine a few days later, this particular aesthetic disagreement would seem to have deep roots.

All of the above items were drawn from a book that I recommend to any programmer. It's *ACM Turing Awards Lectures: The First Twenty Years: 1966-1985*, (Addison Wesley, 1987). Credit where credit is due.

The key to the puzzle from last month is that the stated conditions imply that only Mickey would get any of the loot. That column was a nostalgic aberration, by the way; I once did puzzles like it weekly, encouraged by Maggie Canon, then editor-in-chief of *InfoWorld*, now of *Macintosh Today*. Thanks, Maggie. Credit where credit is due.

Cousin Corbett's Secrets of Software Success, Part VII: The Rule of Point One. This is a corollary to an earlier Secret, but is important enough to merit a Part number of its own. The rule is: use Version i.0 of your product to debug the changes since Version i-1. When the product is relatively stable again, release it as Version i.1. The user version of this rule is: don't buy anything until Version i.1 is released. The authorship of this rule is in dispute. A *PC Week* author may already have published the rule, but he borrowed it from our editor, Tyler Sperry, who claims to have invented it. My cousin Corbett, on the other hand, swears that it's his. All I know for sure is that the inspiration came from Microsoft. Credit where credit is due.

Michael Swaine

Michael Swaine
editor-in-chief

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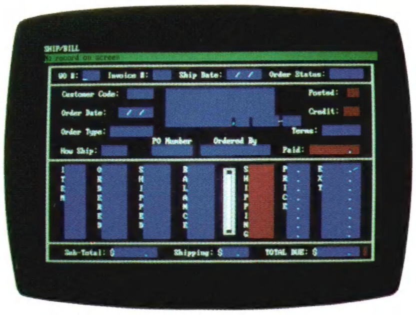

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